POWER

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The Infinite and the Infinitesimal

BY JOS. W. HAYS

It has been said that we Americans like to do things in a big way. We do and we brag about it. We produce and consume upon an enormous scale and we waste out of all reasonable proportion to our consumption.

We are mining coal in the United States at the rate of more than 600,000,000 tons per annum. A few tons more or less are nothing to us. Just call it an even 600,000,000.

We needlessly and heedlessly waste a quarter of all the coal we produce, or 150,000,000 tons per annum. This is an understatement of the waste rather than an overstatement. Engineers who have studied fuel waste in hundreds of plants, big and little, agree that we waste a quarter of all that we produce. Some of it is wasted in handling and storage. Most of it is wasted in burning.

Visualize 150,000,000 tons of coal if you can.

Loaded on coal cars, 40 tons to the car, it would make a train 28,407 miles long, not counting the caboose at the tail end of it. Think of a train of loaded coal cars girdling the earth with a lap over of more than 3000 miles! As you think of it, perhaps you will remember the coal famine and the heatless days of the winter of 1918.

The engine of that train would travel 275 miles before taking the "slack" out of the couplers and starting the caboose.

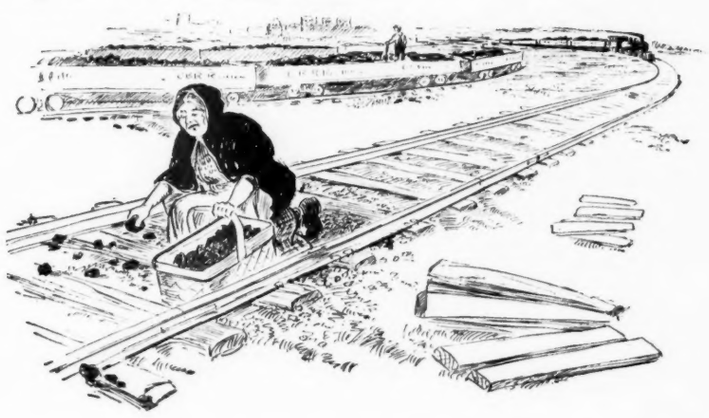
What is 150,000,000 tons of coal worth at the present time, figuring the average "delivered" price per ton paid by the industrial and domestic consumer? Nobody knows, of course, but it must be more than $5. Call it $5, and the wasted coal represents a sum of money sufficient to pay the yearly interest on all of our Liberty Bonds AND THEN SOME.

Looking from the window of a comfortable Pullman, I saw an old woman, with a shawl over her head, picking coal out of the ice and snow in the railroad yards of a big terminal. She was salvaging an infinitesimal fraction of the infinite waste—risking her life among the moving trains for a basketful of coal.

The sight struck me as pitiful and the waste strikes me as criminal.

The coal we are wasting does not belong to us. It is a part of the natural wealth of our country rightly belonging to future generations. We are wasting something given to us in trust and we are guilty of "larceny as bailee." I think I know what posterity will say about us, but I won't tell you because I don't use that kind of language.

WHAT ARE YOU AND I AND THE REST OF US GOING TO DO ABOUT IT?



The Clinker Grinder in Modern Boiler Practice

By CHARLES H. BROMLEY

Deals with the development and application of the clinker grinder. The article shows many of the grinders installed in various power stations and gives performance data of these grinders.

NOT long after the installation of the large Stirling boilers in the Delray Station of the Detroit Edison Co., I watched the men break the huge clinker that accumulated on the dump plate of the stokers under these now famous boilers. Here in this plant was the epitome of modern boiler-room practice. In capacity an extraordinary boiler. There were so many eggs in one basket that everybody in the profession anxiously watched and waited to see how well Alex. Dow was going to carry it now that he had it. Well, he is carrying it yet, and has since put several more in another—the Connors Creek Station.

But the men with the long, heavy bar breaking clinkers—the situation was like walking on all fours up Fifth Avenue amid Packards and Pierce Arrows, like a tom-tom accompaniment to Galli-Curci. This is not said disparagingly.

This excellent piece of coal-burning apparatus had not yet "arrived" despite its excellence. The mechanical clinker grinder or rotary ash discharge had to come to first eliminate the burden imposed upon human muscle in the removal of ash and clinker from the furnace—this is its chief function—to help maintain a shape of fuel bed that would give more complete combustion, and to continuously or intermittently break up and agitate the clinker that the carbon imprisoned in the mass might be made to give up its heat for steam production instead of being dumped, sometimes in appreciably large amounts, into the ashpit; and last, to discharge the ash in such condition that it could be handled by any form of conveyor. These are now accomplished.

But the reader should have in mind that modern clinker grinders are intended for the exceptional rather than for the usual plant. In large stations where the labor is highly competent, reliable and attentive, they will be a success. Where these conditions do not exist, and for the average power plant, they are better out than in, as the ordinary dump plate will serve the purpose just as well. Penalty for abuse and negligence of the clinker grinder will be heavy.

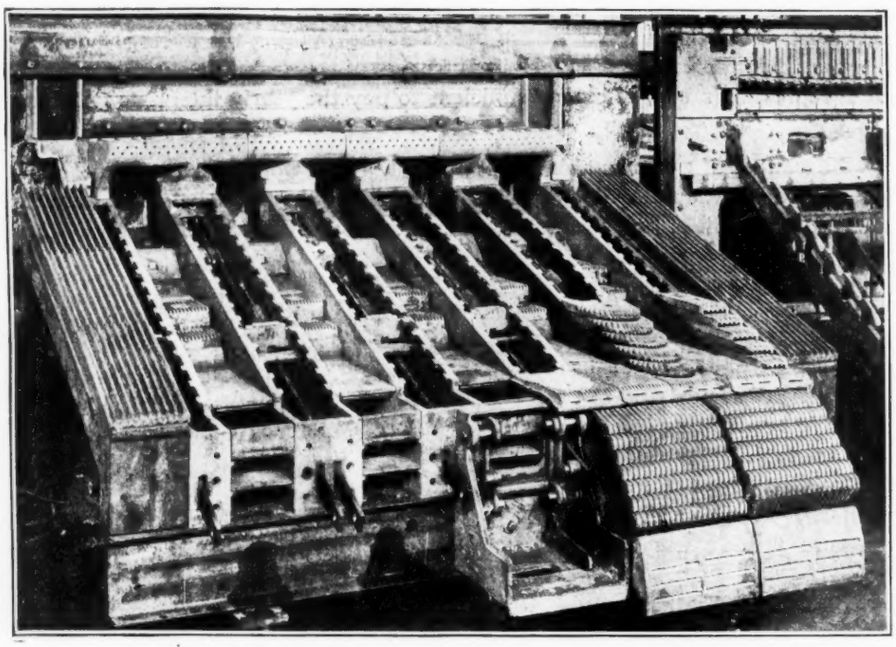


FIG. 1. SHOWING TWO SECTIONS (RIGHT) OF THE OVERFEED GRATES WHICH FORM ONE SIDE OF THE WESTINGHOUSE GRINDER

It is very desirable that a boiler give high combined efficiency over a wide range in capacity, regardless, in a measure, of how much combustible there is in the ash. That is, one must not supply so much air to burn out a little carbon in the ash or agitated clinker that the combined boiler and furnace efficiency suffers due to this excess air. Load conditions for the usual central station demand a boiler rating of about 250 per cent. on peaks. Some stations go higher. A stoker may be made to feed coal so fast that it will not completely burn the fuel as rapidly as it is fed. A lot of coke gets down on the dump plate or dump grate, embedded in clinker so badly that air for combustion, even if the dump plate has air openings, cannot advantageously reach it and it is dumped into the ashpit. This is what happens on peak loads. How serious will be the loss of carbon to the ashpit obviously depends in great measure upon how fast the coal is fed—upon the boiler rating, for boilers not inordinately overstokered and with stokers having no clinker grinders or positive agitation of the clinker. The loss may be said to average about 25 per cent. in most plants, going on occasions to 50 per cent. The loss here referred to means that 25 or 50 per cent. of the total amount of "ash" is combustible. During the period of coal shortage, when everybody was gratified to get coal of any quality, the loss of carbon to the ashpit was higher than usual, supporting the belief that the amount of incombustible in the coal influences this loss, increasing it with increase in incombustible.

The clinker grinder is not new. It has these many years been used with Murphy stokers. Its function is to mechanically remove clinkers from the furnace. The chief function of the clinker grinders of today is the same; but designers aim also to quite completely burn the combustible in the ash and clinker before the latter drop deep into the clinker pit of the grinder; that is, by extending the grate surface, at the refuse end of the

stoker making it movable to agitate the clinker, and by providing air admission at both sides of the top of the clinker pit. The tendency is toward deeper clinker pits to insure that the clinker, when it gets to the rolls or grinder, will be cool to avoid damaging the grinder.

The perforated dump plate, or grate, Fig. 11, as it may be called because it is active grate area, bears relation to the modern clinker-grinder development. As grate surface it is not so active as active surface farther up on the stoker, but it does assist materially in burning out the carbon after the clinker there is broken and agitated either by hand or by the reciprocating overfeed section of the stoker, where such is provided.

The desirability of controlled air admission to the refuse end of the stoker is incontrovertible. But it is obvious that grate openings or dampers alone do not control, since the resistance through the fuel bed may be still more important. Some of the first Roney stokers had dump grates with slotted holes. When the upper part of the fuel bed became heavy, as when low-ash coals were used, large quantities of excess air, following the path of least resistance, went through these openings; in fact, this trouble was so serious that the builders blanked the dump grates.

Where the air to the lower, or refuse, end of the stoker is controlled, some excellent results have been had in burning carbon from the ash. At the Union Gas and Electric Co., St. Louis, tests on a double-dump-grate Westinghouse underfood stoker without clinker grinder gave the results shown in Table I.

Notice that the ash in the coal runs from 16 to 22 per cent.

Where there is no means of sufficiently increasing the air supply to the coking grate or to the extension or dump grate, in relation to the rapidity of feeding coal, a loss results due to insufficient air—that is, to carbon monoxide—because combustible piles upon these grates faster than the grate is able to burn it. The figures of Victor Phillips[1] relative to operation in the Cleveland Railways Co.'s plant are interesting enough to refresh one's mind of the usual magnitude of such loss:

TABLE I. RESULTS OF TESTS ON DOUBLE-DUMP-GRATE UNDERFEED STOKER

Per Cent Boiler Rating	Per Cent. Combustible in the Ash	Per Cent. Ash in the Coal
169.7	18.0	15.9
154.0	11.5	18.3
217.65	....	19.8
153.78	9.5	18.2
174.5	7.5	18.38
176.0	11.5	22.2
165.0	14.0	20.7
159.0	23.0	20.7
170.0	16.0	20.7
164.0	14.0	20.4
170.0	11.2	20.5
189.6	15.0	19.9
178.0	15.0	18.2
116.0	14.0	20.2

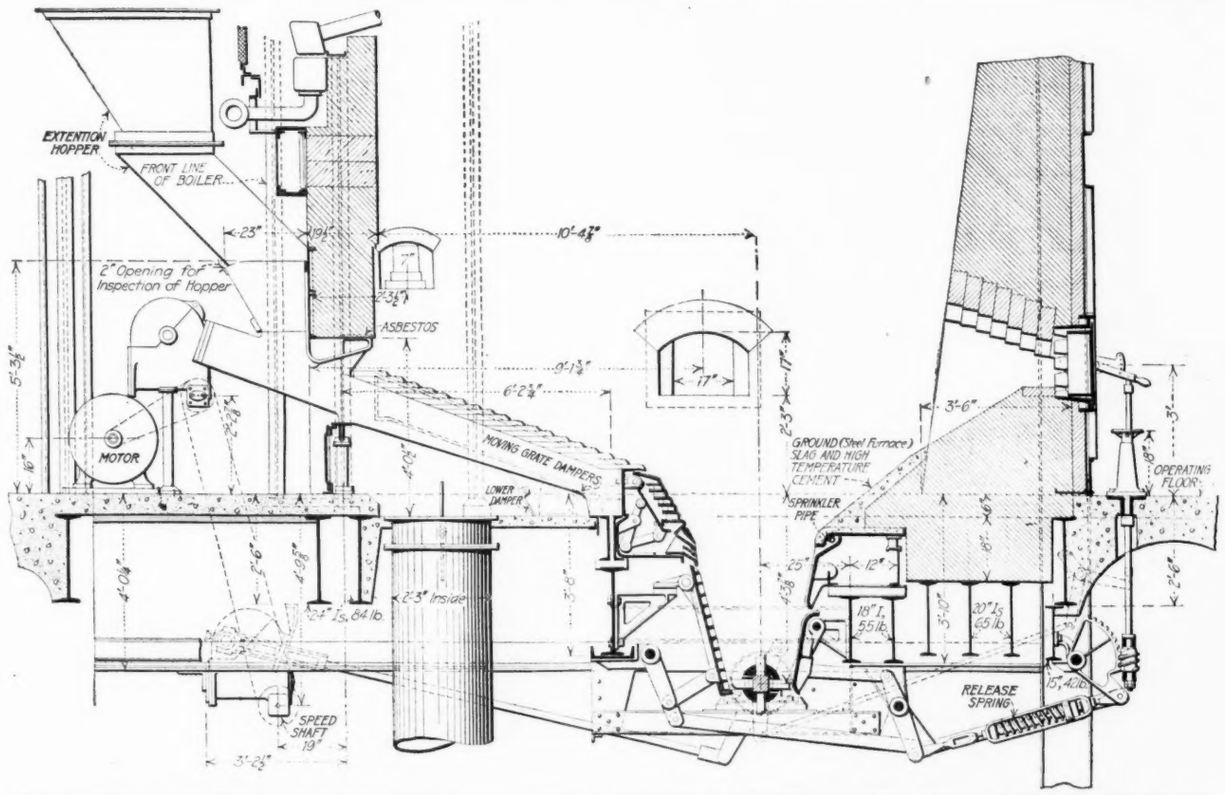


FIG. 2. EDISON ELECTRIC ILLUMINATING CO., BOSTON. CLINKER GRINDER UNDER LATEST SETTING FOR CROSS-DRUM BOILER, WESTINGHOUSE UNDERFEED STOKER. SPRINKLER PIPE USED INSTEAD OF WATERBACK

Fuel Bed Thickness	— Thick —			— Medium —			— Thick —		
Horsepower output of boiler	452	661	895	500	736	923	504	718	907
Ash in coal, per cent	13.2	12.4	12.6	12.4	11.8	11.6	12.5	12.5	13.2
Combustible in ash, per cent	5.1	4.0	7.6	4.6	10.0	7.0	17.3	17.3	20.0
CO loss	0.4	0.8	10.9	6.6	11.2	13.9	14.8	11.4	....

Many tests with a Westinghouse stoker having air admission to the dump grate at one of the Detroit Edison Co.'s stations gave an average of 12 per cent. carbon in the ash. Though I have no figures as to the average boiler rating during these tests, the ratings were all under 200 per cent. and the ash in the coal was less than that in the coal used in the Union Gas

[1] "Relation of Boiler Efficiency to Capacity," presented before the American Society of Mechanical Engineers, Cincinnati, Ohio, May, 1917. Power, July 31, 1917.

and Electric Co.'s tests at St. Louis, where the average carbon in the ash was 13.86 per cent. But the figures serve well when contrasted with tests reported by the University of Illinois on Illinois coal in which the carbon in the ash is from 17 to 40 per cent.

Before taking up specific installations it is advisable to consider the chief things which experience with grinders has taught those who design and those who operate them. As the Murphy grinder is the oldest, the following, from a communication by George I. Bouton, chief engineer of the Murphy Iron Works, is of value.

The disposal of the refuse on a stoker has probably caused more heartaches than any other part of the stoker design. The various stoker builders are continually hunting for some satisfactory means of disposing of the refuse. This was apparently one of the principal problems which confronted Thomas Murphy, and we find it a prominent part of his first patent, dated Nov. 9, 1875, which covers among other things, his revolving-toothed cylinders. In his description he writes in part as follows: "Also, to so arrange the grate bars that every second one may be vibrated to free the grate from ashes and to collect the clinkers and refuse at certain points where they can be removed, or ground up and then removed by toothed cylinders rotated by cranks on the outside of the furnace."

In its original form it was apparently a solid casting. About 1895 the use of steam in connection with the clinker grinders appears, and this is covered by a patent of John H. Nicholson, Oct. 8, 1895. The use of the hollow air-cooled clinker grinder which was connected [by a duct] to the rear end of the flue beyond the boiler damper appeared about 1897.

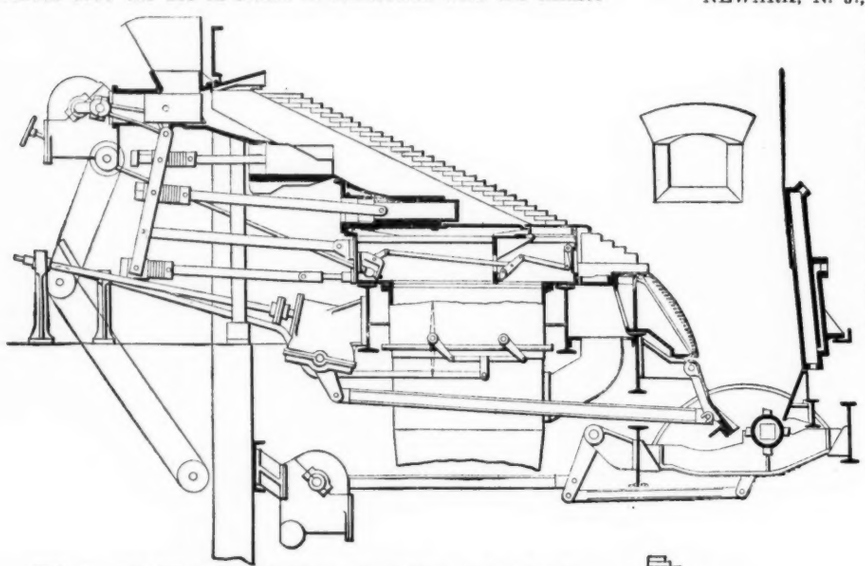


FIG. 3. STANDARD CLINKER GRINDER AND WATER-COOLED BRIDGE-WALL OF THE AMERICAN ENGINEERING CO.

The clinker grinders were cast around a hollow tube or piece of pipe, beginning about 1895. The rear end of the clinker grinder was connected to the flue behind the outlet damper, air being admitted to the front, the idea being that this would keep the clinker grinder cool. A pipe was cast into each side of the grate bearer, and this pipe was provided with a series of holes which were drilled through from the outside. These two lines supplied steam to the clinker grinder and also supplied steam under the lower ends of the grates.

As the stokers got larger, the need for a sectional form of clinker grinder and a sectional form of grate bearer became urgent, and these were developed in the latter part of 1907 or the early part of 1908. The original sectional clinker grinder was made up of 2-in. two-toothed sections strung on a square shaft. A single steam line was placed under the center line of the clinker grinder, but Mr. Fortune, in his patent of Oct. 16, 1909, indicated that additional steam lines might be placed to supply steam under the lower end of the grates. The single steam line was adequate for the coals that were reaching the market at that time. The square bar tended to twist, however, and repairs were difficult, and the final move was to make the bar a round bar, doing the driving through the clinker.

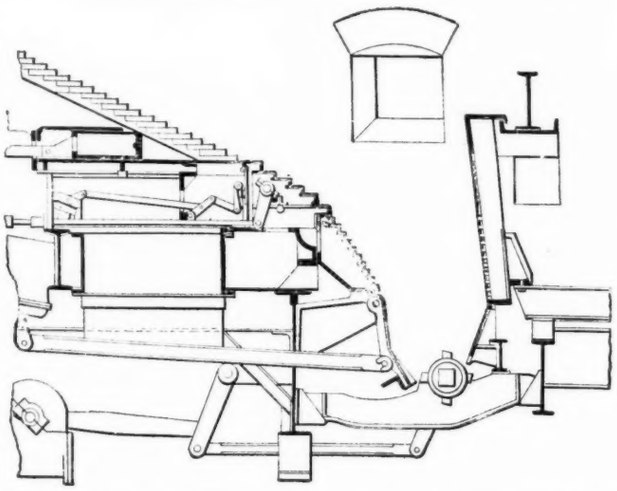


FIG. 4. PUBLIC SERVICE ELECTRIC CO., ESSEX STATION, NEWARK, N. J., AIR-COOLED BRIDGE-WALL.

grinder sections. At the time these sectional interlocking clinker grinders were being developed, the matter of cutting down the capacity of the clinker grinder seemed to be of considerable importance, and one of the early forms of the clinker grinder had a 7-in. body with a total of 9 in. over the teeth; that is, teeth projecting 1 in. from the body. Later, this was changed to a 6½-in. and then 6¼-in. body with 8½-in. over the teeth, and this is our present standard interlocking clinker grinder for the 12-in. grate bearer.

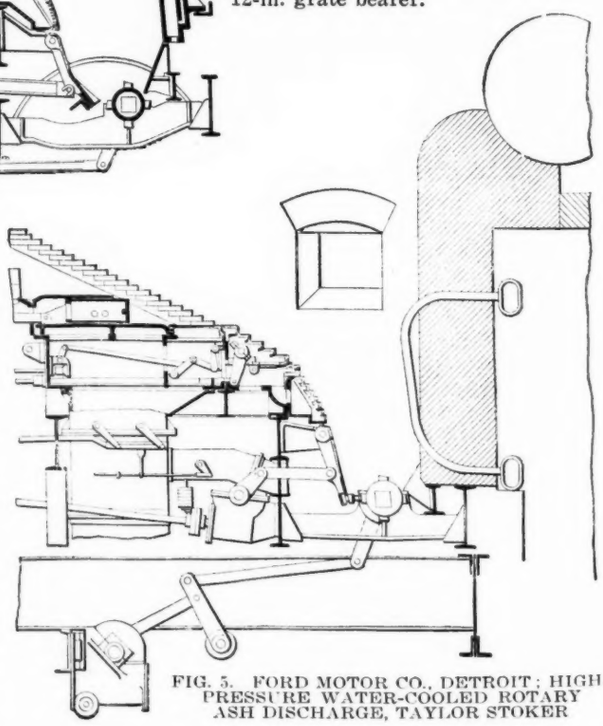


FIG. 5. FORD MOTOR CO., DETROIT; HIGH-PRESSURE WATER-COOLED ROTARY ASH DISCHARGE, TAYLOR STOKER

The tendency with the single clinker grinder was to pile up clinker on the side toward which it ground, while the side from which it ground was likely to be inadequately protected with ash or clinker. On the larger stokers, how-

ever, it was difficult to get sufficient strength for these small double clinker grinders, and shortly after the writer took charge as chief engineer, we reached an agreement in the engineering department that we would not furnish double clinker grinders on a 12-in. bearer for stokers more than 6 ft. deep.

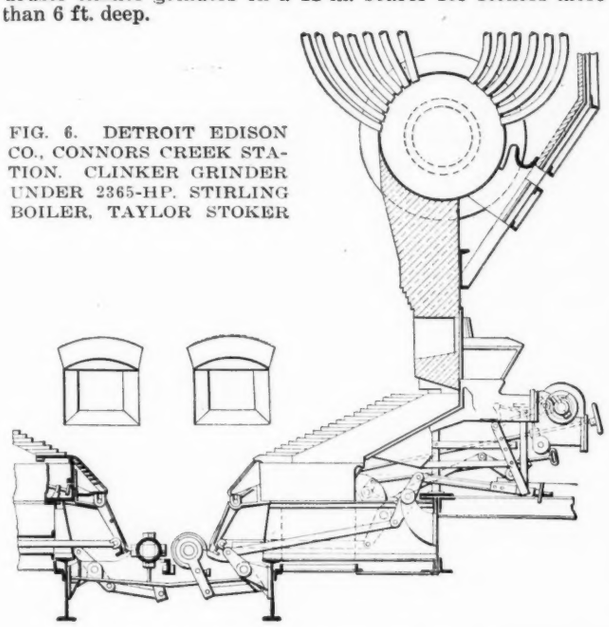


FIG. 6. DETROIT EDISON CO., CONNORS CREEK STATION. CLINKER GRINDER UNDER 2365-HP. STIRLING BOILER, TAYLOR STOKER

To meet the demand for a double clinker grinder for the large stokers, we designed, about four years ago, the 18 in. grate bearer with the two large interlocking clinker grinders. These worked fine on the first installation, which happened to be a coal with ash of high fusing temperature. When we struck ash of a low fusing temperature, however, our troubles began, as the original clinker grinders of this design were equipped with but one steam line, the old practice of the Murphy company being a single steam line midway and slightly below the clinker grinders. This steam line tended to block the free passage from the clinker grinders, and it was removed and a single line under the center of each grinder substituted. This is our present standard practice for these clinker grinders.

Later, to insure the clinker reaching the clinker grinders, we installed steam lines under the lower ends of the grates, which, as already stated, is simply a reversion in type. It does not make any difference how effective the clinker- and ash-removal equipment on a stoker may be, it is absolutely useless unless the clinker and ash reach the refuse-removing device. In other words, if the ash is of low fusing temperature and melts in the upper sections of the stoker, the refuse-removing device is practically useless. The result is little clinker and a large amount of coke in the refuse. For this reason we consider it desirable to use steam under the lower ends of the grates where ash of low fusing temperature is encountered, and stokers going into a territory where we expect to meet this condition are equipped with these steam lines. They are valved so that they can be used or not, as desired.

If, with a coal running 15 per cent. laboratory ash, we get refuse that runs 60 per cent. combustible, a condition which is found on some stokers, the combustible in the ash amounts to 22½ per cent. of the total coal, or about 26½ per cent. of the heat value of the coal. If this combustible in the ash, with the use of additional steam, can be reduced to 20 per cent., a figure which is not at all impossible, the combustible in the ash represents 3¾ per cent. of the coal, or about 4.4 per cent. of the heat value of the coal. In other words, 22.1 per cent. of the heat value of the coal is saved. If it takes 3 per cent., 4 per cent. or 5 per cent. of the steam produced by the boiler to make this saving, the investment is evidently a good one, and so far as the writer has been able to find out, 3 per cent. or 4 per cent. of the steam produced by the boiler will kill the clinker in any coal we are likely to meet.

According to our present standards, we use 8-in. grate bearers and small single interlocking clinker grinders on stokers 6½ ft. wide and smaller. We use 12-in. grate bearers and large single interlocking clinker grinders on stokers 7 ft. wide and larger. We use 18-in. grate bearers and large double interlocking clinker grinders on stokers where the local conditions seem to make their use advisable. These are seldom used, however, on stokers less than 8 ft. wide, though we have used them on the 7 x 6-ft. stokers at the Blackstone Hotel and the 6 x 5-ft. stokers at Oglesby. The coal at Oglesby was about as bad as one is likely to find so far as the ash content is concerned. The laboratory ash ran 25½ per cent. The ash was plastic at 1976 deg. F. and fused at 2120 deg. F. It was quite an impossible situation until more steam was added under the grates and under the clinker grinders.

All clinker grinders have steam lines directly below them. This means that there is one steam line where single clinker grinders are used and two where double clinker grinders are used. Steam lines are provided under the lower ends of the grates on stokers which are to burn Ohio, Indiana, Illinois or Michigan coal.

Some typical performance figures of the Murphy grinder follow:

PERFORMANCE OF MURPHY FURNACES

Rated Horsepower of Boiler	Per Cent. Rating of Boiler	Combined Efficiency, Per Cent.	B.t.u. Coal as Fired	Per Cent. Ash in Coal	Per Cent. Combustible in Ash
253.8	134.35	80.34	12,130	14.97	14.86
253.8	159.3	76.28	13,217	11.81	12.19
143.1	119.0	73.58	13,318	12.64	16.87
			Dry Coal		
143.1	172.66	74.84	12,672	16.43	17.19
			Dry Coal		

In developing the grinders now being applied to underfeed stokers the designers of the Taylor stoker

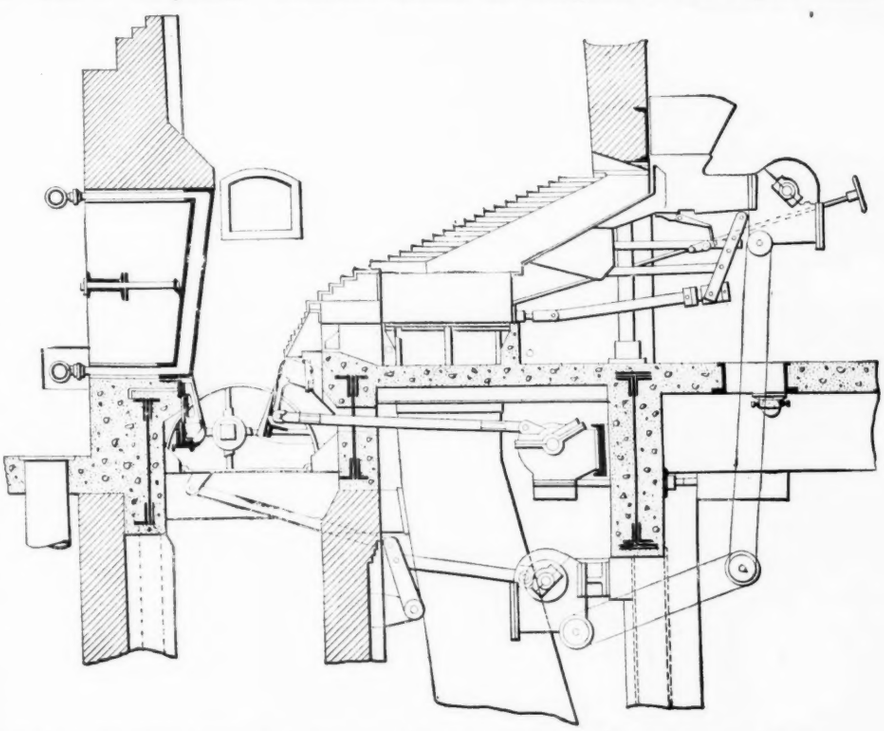


FIG. 7. BEACON LIGHT CO., CHESTER, PENN. WATER-COOLED BRIDGE-WALL, TAYLOR STOKER

found by actual try-out that in the clinker pit moving metal projections in contact with hot clinker were prohibitive, as they rapidly burned away.

About 1910 the suction vacuum system of ash removal was coming into wide use. To successfully handle ashes in this system they must be neither too wet nor too hot. The clinker grinder that used water for cooling the grinding roll had, therefore, to get along without water or with so little of it that the ashes are reasonably dry when discharged.

The designer of the modern grinder strives for the following:

1. To have cool clinker in contact with the grinding roll. To accomplish this he must provide a clinker pit sufficiently deep and of adequate volume to admit of letting the clinker lie in the pit long enough to cool before grinding, and to accomplish these under the combustion rates prevailing in everyday plant operation and with the coals available to the plant.

2. To give wide flexibility of ash-discharge rate through the grinder and provide for dumping at once the entire content of the clinker pit.

3. To get a pit of such depth and shape that when it contains a normal quantity of ash and clinker, the mass in the pit will resist the passage into it of air from the overfeed or other part of the stoker; that is, so resistant to air and gas flow that these will be directed upward into the combustion space and not down into the mass in the pit, where its presence might accelerate combustion of the carbon there and damage the grinding roll and other parts by overheating them. It is seen, therefore, that the clinker should not be allowed to arch up or bridge on the lower part of the stoker and thus form or encourage the formation of an air passage directing air toward the bottom of the clinker pit.

4. To provide a rugged grinding roll.

5. To provide an air-cooled or water-cooled back for the brick wall side of the pit to avoid the sticking and growth of clinker to this wall.

6. To discharge the clinker in small particles, cool and reasonably dry.

The first of the modern clinker grinders was applied to a Taylor type stoker in the plant of the builder of the stoker in 1911. The following year a grinder, Fig. 6, was used under one of the 2365-hp. double Stirling type boilers in the Delray Station of the Detroit Edison Co. This grinder had a shallow clinker pit—a too shallow pit—but this was unavoidable.

The grinders for the boilers in the Connors Creek Station and in the large Park Place heating plant in Detroit, both of comparatively recent construction, have pits much deeper than the one in the Delray Station.

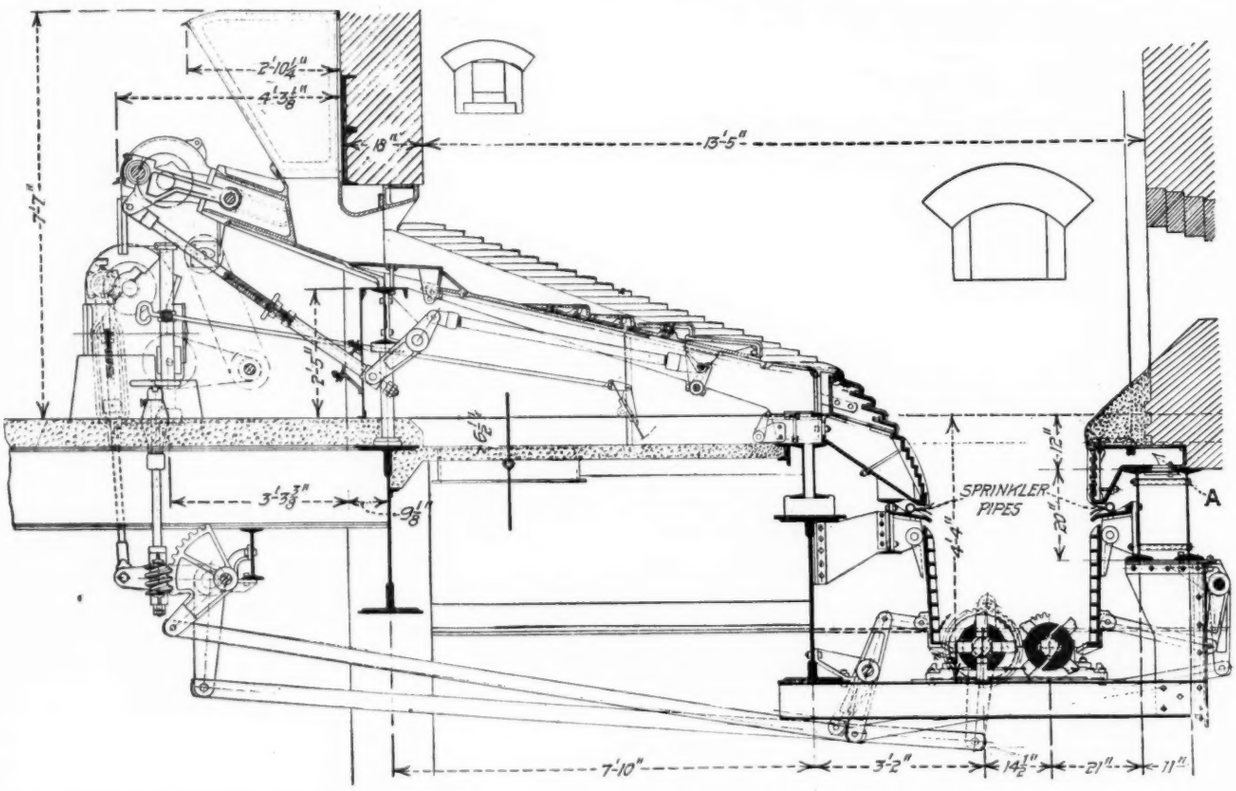


FIG. 8. COMMONWEALTH EDISON CO., CHICAGO. WESTINGHOUSE TYPE CLINKER GRINDER
Note volume of clinker pit, the sprinkler pipes and double rollers, also air admission at *A* under bridge-wall. An unusually interesting grinder.

Following are some figures giving the combustible in the ash from the Delray plants. While the grinders in No. 2 power house show an appreciable reduction in combustible in the ash compared with operation there without grinders, the results are not as good as those obtained today.

ASH ANALYSIS DELRAY STATION, 1916

Month	Per Cent. Combustible in Ash — Power House No. 1 Dumps	Power House No. 2 Dumps	Power House No. 2 Grinders
March	17.524	17.662	14.074
April	17.632	24.278	17.048
May	14.758	21.402	16.608
June	21.685	21.412	16.650
July	18.640	27.727	15.658
August	22.172	26.424	16.222
September	22.170	34.285	20.702
October	23.345	30.752	18.137
November	21.96	20.982	18.998
December	.....	.....	.....

In the Park Place Station the crew had in 1916 begun to get the combustible in the ash down to a gratifyingly low percentage as will be seen from the figures following. So many of the engineering staff of the Detroit Edison Co. have been in Government service during the war that recent performances of the clinker grinders in the company's plants are not forthcoming.

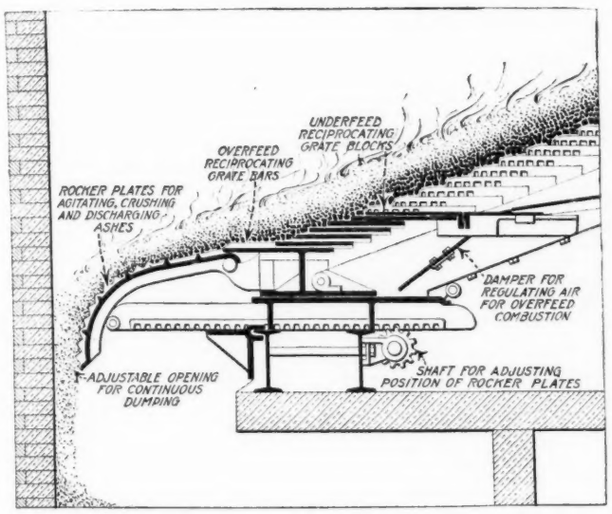

UNDERFEED RECIPROCATING GRATE BLOCKS
OVERFEED RECIPROCATING GRATE BARS
ROCKER PLATES FOR AGITATING, CRUSHING AND DISCHARGING ASHES
DAMPER FOR REGULATING AIR FOR OVERFEED COMBUSTION
ADJUSTABLE OPENING FOR CONTINUOUS DUMPING
SHAFT FOR ADJUSTING POSITION OF ROCKER PLATES

FIG. 9. THE ROCKER PLATES MAY BE RAISED OR LOWERED TO INCREASE OR DECREASE THE DISTANCE BETWEEN THE PLATES AND THE BRIDGE-WALL

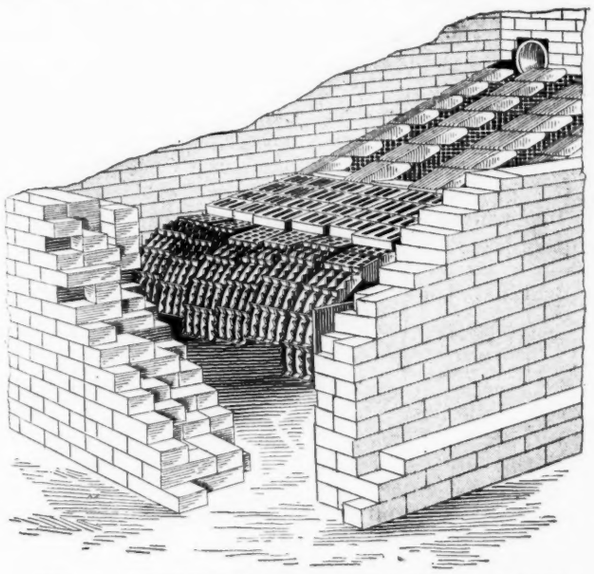


FIG. 10. LOOKING TOWARD THE ROCKER PLATES

About 1913 a grinder which was a development of and an improvement on the old Murphy grinder was attached to a Taylor type stoker in the plant of the Rochester Railway and Light Co. There was practically no clinker pit owing to lack of space to accommodate it.

PERCENTAGE CARBON IN ASH WITH CLINKER GRINDERS, PARK PLACE, 1916

January	11.997	May	11.865	September	8.325
February	12.954	June	9.942	October	6.907
March	13.672	July	16.380	November	8.280
April	13.847	August	38.160	December	9.342

The standard clinker grinder furnished with the Taylor type stoker is shown in Fig. 3. Notice that to the left of the roller is a movable plate, called a crusher plate, which may be moved toward or away from the grinding roller, thus enabling the operators to grind the clinker coarse or fine and discharge it slowly or fast as required. Notice also that the dump plate may be dropped to the wide-open position. To prevent clinker sticking to the extension grate at the foot of the tuyeres, the grate is given a pitch that will drop the clinker by gravity yet give a change in slope that will not be abrupt enough to split the fuel bed.

The air admission to the overfeed grate is controlled from the boiler front, the purpose of the grate being, of course, to consume the combustible before it gets on the grinding roll. Each roller is made up in sections bolted on a square bar. It may be driven from the main stoker drive or separately, with variable speed. The roll revolves slowly and only a part of its surface is exposed directly to the hot clinker. The chief function of the waterback is to prevent clinker "freezing" to the bridge-wall. The waterback in the standard Taylor grinder is not under pressure, and the inlet and outlet openings are accessible for convenient observation and inspection.

Fig. 2 shows an interesting clinker grinder used with a Westinghouse type stoker in one of the latest types of boiler settings in the L Street Station of the Edison Electric Illuminating Co., Boston. The air admission to the lower part of the stoker is controlled, and the air openings in the lower part of the extension grate, just above the crusher plate, are directed downward. The clinker pit, if one may use that term to designate the volume above the grinding bar and up to the extension grate and bridge-wall, is very

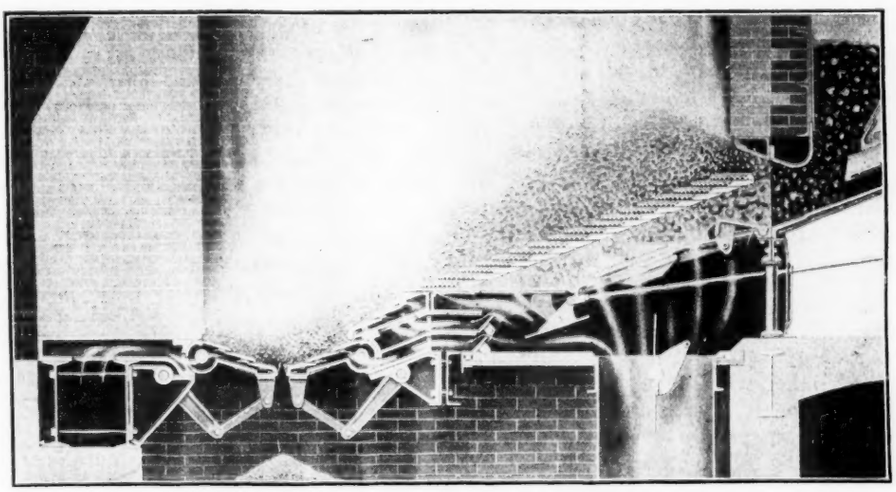


FIG. 11. SHOWING THE DOUBLE DUMP GRATE WITH AIR ADMISSION THROUGH HORIZONTAL OPENINGS IN EACH GRATE

deep, being 3 ft. 10 in. The purpose of such a depth is to insure that the clinker will be cool before it reaches the bar. No waterback is used, but instead a sprinkler pipe located where it will be most difficult for it to become plugged with ashes and dust is used to cause a film of water to flow over the plates, cooling the clinker so that it does not adhere to the plates. Of course the water therefore keeps the grinding bar cool.

The coals usually burned in this station are the low-ash Eastern coals. The grinder has not been in operation long, but the carbon in the ash discharged by it now averages about 7.5 per cent. with New River coal.

Fig. 8 shows a clinker grinder used with a Westinghouse type underfeed stoker in one of the stations of the Commonwealth Edison Co., Chicago. Notice particularly the slope of the overfeed extension-grate part

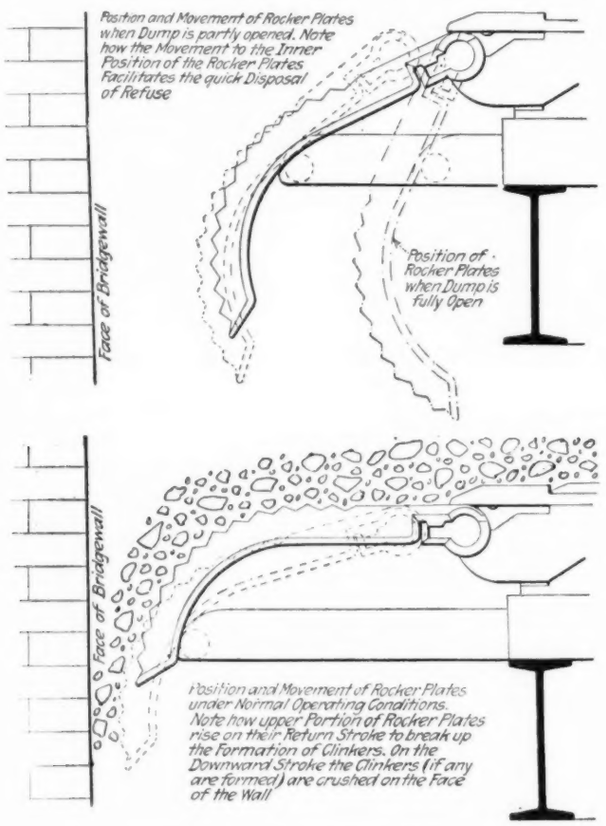

Position and Movement of Rocker Plates when Dump is partly opened. Note how the Movement to the Inner Position of the Rocker Plates Facilitates the quick Disposal of Refuse
Face of Bridgewall
Position of Rocker Plates when Dump is fully Open
Face of Bridgewall
Position and Movement of Rocker Plates under Normal Operating Conditions. Note how upper Portion of Rocker Plates rise on their Return Stroke to break up the Formation of Clinkers. On the Downward Stroke the Clinkers (if any are formed) are crushed on the Face of the Wall

FIG. 12. SHOWING THE VARIOUS POSITIONS OF THE RILEY ROCKER DUMP PLATE

of the stoker. These grates move, of course, and have air passages in them, the purpose being to agitate the clinker, breaking it and exposing to the air for combustion the combustible contained in it.

As far as air supply is concerned, one notices also in this grinder that an auxiliary air duct is provided in the bridge-wall at *A*, and air is discharged into the clinker mass from the bridge-wall side as well as from the overfeed-grate side. Sprinkler pipes and adjustable crusher plates are provided. Notice that two grinding rolls are used. The clinker pit is one of the deepest yet used, being 4 ft. deep. The experience of the designers of the Taylor-stoker clinker grinder convinces them that air-cooled backs for the bridge-walls are impracticable for most plants, owing to the large cooling surface required. Water-cooled backs are not without disadvantages, but they are the most practicable, in the judgment of these designers. The low-pressure waterback is, of course, more widely used than the high-pressure. Fig. 4 shows an air-cooled back, and Fig. 5 a high-pressure water-cooled back.

The clinker grinder or crusher standard with the Riley type stoker differs from the grinder or rotary ash-discharge machines described herein. The overfeed reciprocating grates do not have a steep slope as they approach the clinker or rocker plate, but have the same inclination as the underfeed grates. The rocker plate with which nearly all engineers are familiar, but which it is necessary to describe here, to be complete, is made up in sections as shown in Fig. 10. Each section has an up-and-down movement in the opposite direction to the motion of its immediate adjacent section; that is, each section end next the bridge-wall moves vertically. The purpose is to agitate and crush the clinker. The distance between the rocker plate and the bridge-wall is adjustable to give continuous dumping of the ash (see Figs. 9 and 12).

While this clinker-crushing and agitating device is simpler than the rotary ash-discharge machines, it functions well, as the following performance figures reveal:

Rated Boiler Horsepower and Station Name	Per Cent. Rating	Combined Efficiency Per Cent.	B.t.u. Value of Coal	Per Cent. Ash in Coal	Per Cent. Combustible in Ash
1373 Essex Station, Public Service Electric Co., Newark, N. J.	102.7	80.2	13,916	10.40	11.84
	110	81.1	14,410	7.36	15.43
	141	81.8	13,836	10.81	11.44
	145.2	81.4	14,086	10.53	16.67
	148.1	80.5	14,206	9.58	14.57
	153.9	78.5	14,234	8.71	10.64
509, Interborough Rapid Transit Co., New York City	209	72.2	14,534	7.00	4.9
	233	72.0	14,511	7.11	14.29
	331	68.4	14,001	9.95	21.57
444	302	76.4	10,775	15.34	20.26

Considering the simplicity of the device compared with rotary grinders, the rocker plate produces surprisingly good results in the way of burning out combustible in the ash, for it is to be presumed that an amount of combustible reaches the rocker plate comparable to the amounts usual with other underfeed stokers.

The engineers designing the Riley type stoker have been reluctant to adopt the clinker grinder or rotary ash discharge as developed up to date, though their affiliation with the Murphy Iron Works puts them in possession of much valuable experience. Sanford Riley points out to me that experience shows that for the commercially complete burning out of combustible in clinker at the refuse end of any stoker, agitation and breaking up of the clinker at the points of air supply and before the grinding bars are closely approached by the combustible is vitally essential to efficient and successfully continuous operation. Of course this is true generally, and particularly for coals the clinker of which is dense instead of porous.

The coal-mine mechanic must be resourceful. He must keep the mine machinery going whether he has anything to keep it going with or not. If an engine or pump breaks down and no spare or repair parts are to be had, he must repair it anyway and keep it running, says *Coal Age*. Otherwise the mine may be compelled to shut down, either in whole or in part.

Some engineers are of the opinion that any kind of coal can be burned on any kind of furnace grate. It is better to know what kind of grate to use before installing than to learn by failure.

"Karge" Cushion and Flexible Coupling

Many designs of flexible couplings have been used for connecting shaftings in order to eliminate mechanical troubles due to misalignment, and although they have served their purpose to good advantage, there is always room for improvement This seems to be borne out by the introduction of the "Karge" cushion and flexible coupling manufactured by the Three Rivers Machine Tool and Die Corporation, Phoenix, N. Y. The coupling is designed to take the place of flexible joints, gears, pulleys, beltings and any other mechanical devices used for the transmission of power. Its claims are that it reduces friction, absorbs shock, protects vital mechanism, needs no lubrication, promotes smooth action among working parts and permits of no slipping between the driven and driving units. The cushion coupling is constructed of a special alloy steel and consists of a coil within a coil, wound in opposite directions. In other words, the coupling proper is formed in a cylindrical shape, so that it resembles a helical spring in appearance, and this coupling member is shrunk in the sleeve at each end. This means being secured to the shaft or machine, as the case may be. A flexible arbor extends through the center of the coil, with a clearance between which allows free elasticity of the coil over the arbor and will prevent the coil from going beyond its elastic limit. At the same time it utilizes the tensile strength of the steel, which is greater than the torsional strength of the shaft. A flexible sleeve is also placed on the outside of the coils for the same purpose as the arbor.

Where the flexible coupling is applied to a shafting or as a connection between two units, it can be bent and placed at almost any angle and will absorb all shock and strain and deliver a load in a satisfactory manner.

Fig. 1 shows the details of construction. The end of the coupling is secured to the shaft by either a key or setscrews, as shown at *B* and *C*. The space between the plug and the floating arbor is to allow for contraction and expansion of the spring lengthwise, as shown at *D*. The space between the coupling and sleeve is to allow for contraction and expansion of the spring lengthwise, as shown at *E*. As already stated, the floating arbor *F* limits the contraction of the spring and has a sliding movement in the plug *G*, which plug makes the end of the spring solid, and the sleeve *H* limits the expansion of the spring and has a solid sliding movement in the coupling.

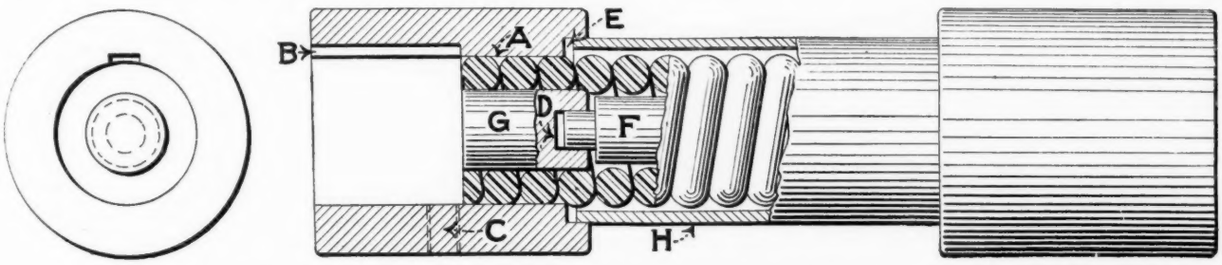


FIG. 1. SHOWING DETAILS OF CONSTRUCTION OF THE "KARGE" FLEXIBLE COUPLING

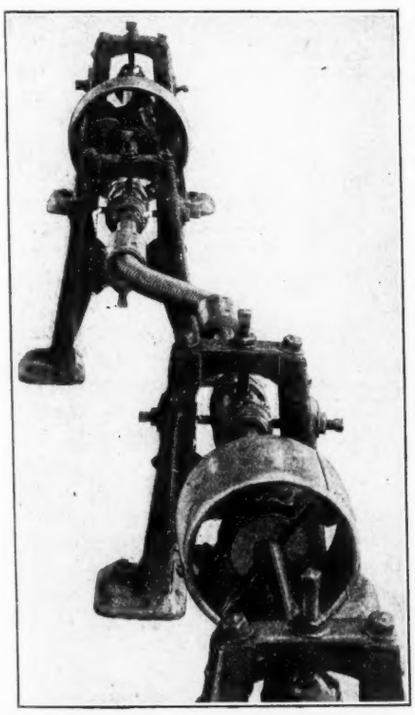


FIG. 2. COUPLING WITH OFFSET

Figs. 2 and 3 illustrate two applications of the flexible coupling, one showing a decided offset and the other a right-angle turn. All couplings are made of cast iron and the compression sleeves of steel. It is the practice to make the inside diameter of the coil spring the same as the outside diameter of the shafting with which it connects. When constructed in this manner, the couplings are claimed to have 30 per cent. more strength in torsion than the solid steel shaft. The devices are at present made in various sizes for shafting from ½ to 6 in. in diameter.

Government Has Its Own Coal Yard

A Government coal yard, supplying the various Federal departments and buildings, will begin operations in Washington on May 1. The yard is capable of handling 1200 tons daily and has a storage capacity of 30,000 tons. The decision of the Government to handle the coal for its own use was made as a result of the success of the Interior Department in doing so last winter during the coal shortage. Accordingly Congress appropriated over $400,000 for constructing the yard and over a million for maintenance and operation.

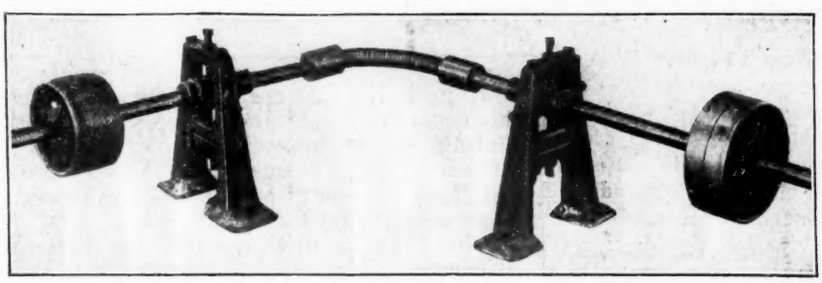
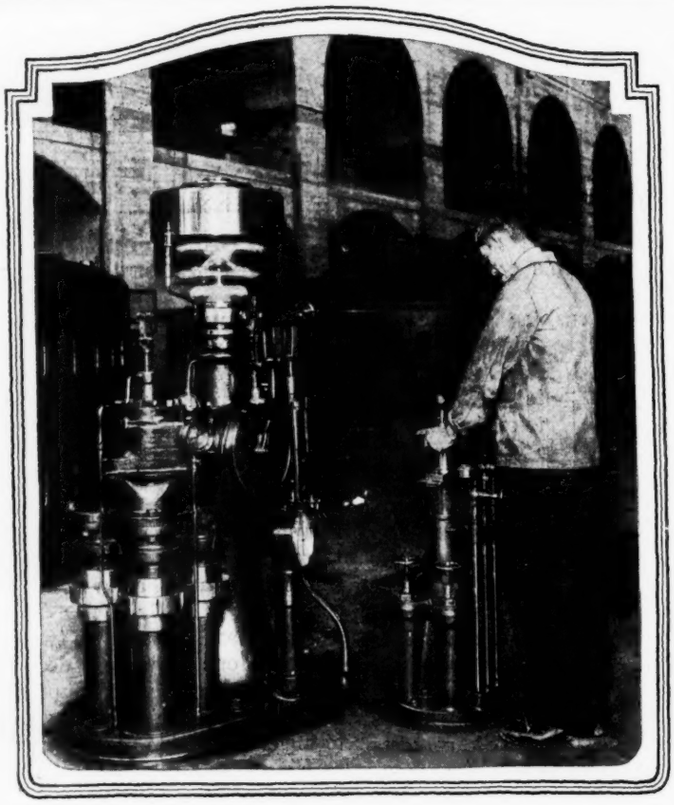


FIG. 3. COUPLING WITH RIGHT-ANGLE TURN

GOVERNORS at HOLTWOOD

By F. H. Rogers*



THE governors at the hydro-electric station of the Pennsylvania Water and Power Co., at Holtwood, Penn., control the speed of five 13,500-hp., two 17,000-hp. and one 16,500-hp. turbines. It is not the intent of this article to describe the mechanical details of these governors, but to cover the subject of regulation in a broad sense by a discussion of the principal requirements of governors for hydraulic turbines and the methods of securing, in the design and construction of the governor, the desired results as exemplified in the Holtwood Station. [The first of the Holtwood articles, telling how the power-house crews are trained, appeared in *Power*, Mar. 25.] The principal mechanical elements that must be used in all governors consist of: (1) A governor head driven from the turbine shaft, containing flyballs controlled by springs, the flyballs being connected to a pilot valve controlling the main governor valve; (2) a first compensation consisting of restoring mechanism connecting the gates of the turbine to the pilot valve; (3) a secondary compensation.

This combination of elements functions in the following manner: When a load change occurs on the generator, the resulting speed change causes the flyballs to move from their central position and this operates through a pilot valve and the main governor valve, causing the turbine gates to move. As the gates operate, the pilot valve is moved back toward its central position by the restoring mechanism, but owing to the unbalance between load demand and power supply, the speed continues to change and the gates to move. When the position of balance between demand and supply is reached, the speed ceases to change so that a slight additional movement of the gates restores the pilot valve to its central position and stops the gates. At this point in the operation, the speed of the generator is either too high or too low, depending on whether the change in load is a reduction or an addition, and the speed must therefore be brought back to normal. This is accomplished by the secondary compensation acting through the pilot valve. The requirements for a governor for hydraulic turbines may be divided into the following headings: (1) Regulation, (2) Steadiness or stability, (3) Reliability, (4) Simplicity, (5) Durability. That a governor may properly regulate the speed of the unit, it should be sensitive; that is, respond quickly to sudden changes of speed and also to slight changes of speed. The quality of steadiness, or stability, is an important one and involves freedom from unnecessary gate movements or movements occasioned by conditions other than changes of load on the unit. Thus, not only is it necessary for a governor to respond to changes of load, but it is equally important that it shall not act when there is no change of load.

The reliability of the governor is of as great importance as the reliability of the turbine itself, since the operation of the turbine depends on the governor that controls it. Therefore, an unreliable governor is a continuous source of risk in the operation of the turbine unit altogether aside from the question of the speed regulation obtained.

Owing to the unusual requirements in connection with the governing of hydraulic turbines, the governor must of necessity be a complicated mechanism. So it is of importance to simplify the design and method of operation of the governor as far as possible without detriment to the performance required of it. In most hydro-electric stations the cost of main-

Holtwood is on the Susquehanna River about fifteen miles from Lancaster, Penn., and forty from Baltimore. At present the hydro-electric station, owned by the Pennsylvania Water and Power Co., has a capacity of 118,500 hp. in eight units generating 83,500 kw.; the head is 63 ft. Current at 70,000 volts is transmitted to Baltimore and Lancaster.

*Hydraulic Engineer, William Cramp & Sons Ship and Engine Building Co., Philadelphia.

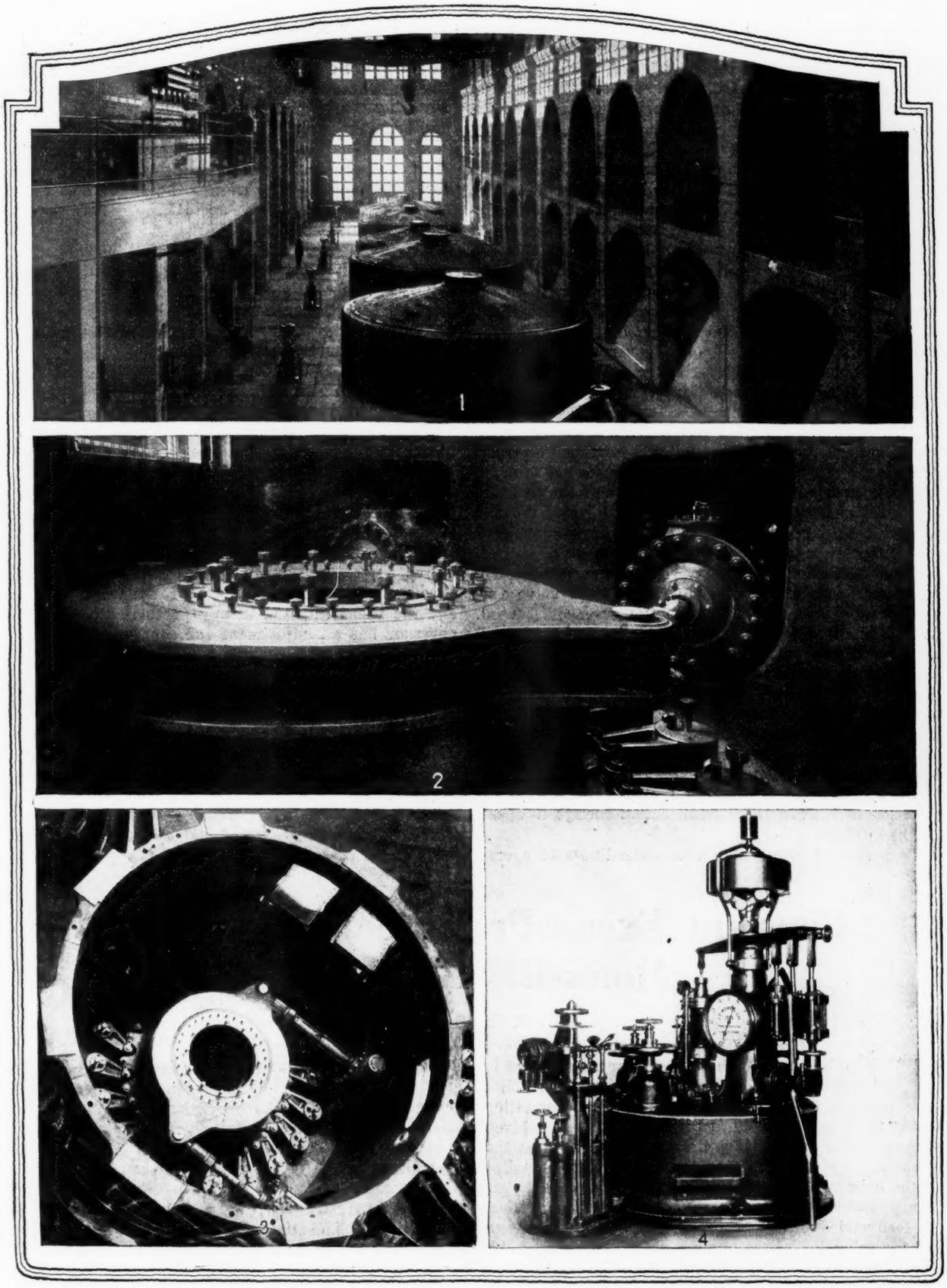


FIG. 1. INTERIOR OF GENERATOR ROOM, HOLTWOOD. FIG. 2. LOOKING TOWARD THE OPERATING CYLINDERS. FIG. 3. TYPE OF TURBINE IN WHICH OPERATING MECHANISM IS SUBMERGED. FIG. 4. THE I. P. MORRIS DOUBLE FLOATING LEVER GOVERNOR

tenance of the governor is higher than the maintenance of all the rest of the turbine and it is therefore economical to install the most serviceable governor that can be obtained, irrespective of first cost, to insure continuous operation of the unit without the necessity of shutting down for repairs or adjustments to the governor.

The governor is made extremely heavy and rigid, so that the design is in keeping with the heavy construction characteristic of the large hydraulic turbines. The governor head is extremely powerful; that is, the flyballs are heavy so that a comparatively small change in speed produces a great centrifugal force to actuate the pilot valve. That as much of this power as possible may be available to move the pilot valve the friction in the connections between the flyballs and pilot valve is reduced by the use of ball bearings at all joints, securing the sensitiveness required of a governor which must respond quickly to sudden changes of speed and one which will move the gates for every slight change in speed.

The use of a heavy governor head also results in steadiness in operation, so that the governor does not function when there is no change of load. It is often noted in hydraulic plants that the gates of the turbines are constantly swinging back and forth when no load change is taking place. This is spoken of as hunting of the governor and may be due to a number of causes, such as variation in the governor pressure, defective drive or mechanical friction in the valve or valve connections. Where a light commercial governor is used, this constant swinging of the gates is noticeable and soon starts wear in the operating mechanism of the turbine. Such wear results in a cumulative increase in the movements which caused it, so that the hunting increases. These defects are greatly reduced by the elimination as far as possible of friction in the connections and the use of a powerful governor head, as the heavy flyballs will resist any outside influences tending to move them from their central position, and will function only when there is an actual change in speed of the machine.

To prevent hunting and insure steadiness of operation, it is of vital importance to eliminate all lost motion in the restoring mechanism In the I. P. Morris double floating lever governor all gears, screw threads, or racks, are omitted in the restoring mechanism, making all connections between the parts constituting the restoring mechanism by means of hardened steel pins and bushings, ground to a fit.

A governor should have as few and as simple adjustments as possible for the functions which it has to perform and must be so designed that these adjustments can be made while it is in operation. Among these adjustments might be mentioned:

1. Change of Normal Speed of Unit—This adjustment is required for synchronizing the unit. The governor is fitted with a handwheel and motor for this purpose, so that the speed of the turbine may be altered either at the governor or through the motor from a distant point such as the switchboard.

2. Inherent Speed Change—This adjustment is required so as to give a change in normal speed from full-load to no-load conditions, so that the generators may be properly operated in parallel and equally divide the load. This governor is furnished with a small handwheel connection so that the inherent speed change from no load to full load may be altered anywhere between limits of zero to 3 per cent. This adjustment may be made while the governor is in operation.

3. Time of Gate Movement—This adjustment is required so that the turbine gates may be moved in a time period to suit the length of the water passages and the velocities used in any particular plant. This governor has an adjustment for changing the time of gate movement which can be made during the operation of the governor, although it is usual in a given plant when the governor is first installed to fix this time of gate movement to suit the local conditions.

[*The article which will follow this one deals with Normal and Abnormal Operation of the Governor System, of which the governor itself is only a part. Next will come one treating of how the governor system is maintained at Holtwood, followed by others dealing with details of operation and maintenance of particular parts of the system.*—Editor.]

Constant Excess-Pressure Regulator for Motor-Driven Pumps

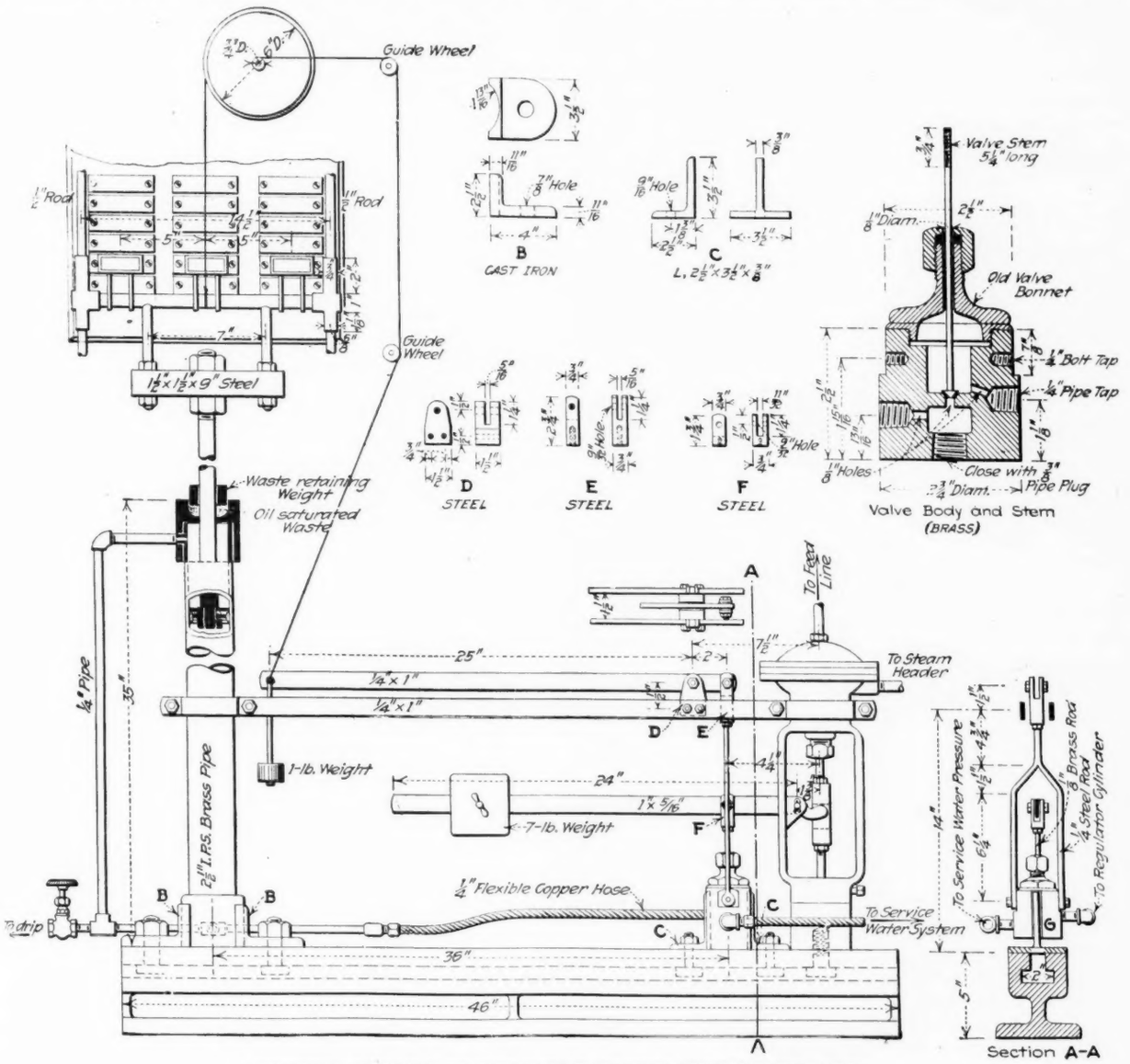
By C. H. SONNTAG

THE maintenance of a constant excess pressure in boiler-feed lines over the pressure in the boiler is of decided advantage. When hand regulation of the individual feeds is used, it means that a given opening of the feed valve will always feed water at the same rate. If automatic feed regulators are installed on the boilers, this point is not quite so important, but in any event the building up of high pressure when the feed valves all happen to close at once is prevented, and the operation of the pump is controlled without the necessity for personal attention.

Control of steam pumps on this principle has been worked out by several makers who furnish regulators for the purpose, but so far as the writer knows, the control of motor-driven pumps along the same lines has not come into general use. In our plant the boiler-feed pumps are fitted with constant excess-pressure governors, but we had more exhaust steam than we needed to heat our feed water, so we installed a motor-driven triplex-feed pump, which gave us the benefit of the superior steam economy of our main generator.

The accompanying drawings show the regulator that we designed for the control of this pump. It works on the familiar follow-up motion principle, such as is used on steam steering engines and similar devices. The base casting was made from an old motor rail. The diaphragm chamber and parts below it are from a 1½-in. constant excess-pressure steam-pump governor. The motor used is of the wound-roter type, and the three brush-holders of the regulators, being in metallic con-

tact with their supporting arm, short-circuit more or less of the resistance in the rotor circuit, according to their position on the face of the contact panel. The subdivisions of the rotor resistance are equal in the three phases, but the dimensions on the panel drawing show that corresponding sections of this resistance in the three phases are shunted successively instead of at the same time. This gives three times as many subdivisions of speed as there are contacts on the panel, and the result is very smooth acceleration, with a speed for almost any rate of feed. Of course it slightly unbalances the rotor currents, but with so many divisions there has been no untoward behavior of the motor.



SHOWING DETAILS OF THE MOTOR-DRIVEN PUMP REGULATOR

This regulator does not open the primary circuit of the motor, nor stop it, but if the resistance is properly chosen, it will bring the motor down to a very low speed. The pump is fitted with a spring-loaded relief valve set above the working pressure, as a safety device in case of absolute stoppage in the discharge line. The panel is so connected to the resistance that the lowest position of the brushes shunts all the resistance.

To start the pump and regulator in service, see that the valves leading to the upper and lower diaphragm surfaces are open, also the one supplying service-water pressure to the follow-up. The drip valve should be open enough to let the plunger and brush rigging down slowly when the follow-up valve is closed. Then hold the follow-up valve open by raising the upper lever until the brushes are at the top of the panel and close the primary switch, when the motor will start slowly. Release the follow-up valve and the motor will accelerate until the desired excess pressure is reached. This excess pressure is determined by the position of the 7-lb. weight shown on the lever arm in the illustration. Fifteen pounds is about right for boiler feeding.

The application of the follow-up principle to this purpose, and most of the details of the regulator were worked out by our chief engineer, C. A. Crass. He later became first assistant engineer of the Emergency Fleet Corporation Steamer "Lake Edon," and was killed when that vessel was torpedoed in European waters on Aug. 21, 1918.

Protecting Polyphase Induction Motors from Single-Phase Operation

By B. W. JONES
Engineer, Industrial Control Department, General Electric Company

Comparison is made of the different means generally employed to prevent a polyphase induction motor from operating single-phase and also from overheating.

TWO-PHASE and three-phase induction motors are used for a great number of applications where polyphase alternating current is available. The current per phase of a three-phase motor is more than the current per phase of a four-wire two-phase motor having the same horsepower and voltage rating. To illustrate, the full-load current per phase of a 40-hp. three-phase 220-volt induction motor is approximately 100 amperes, and the full-load current per phase of a two-phase motor of the same rating is approximately 87 amperes.

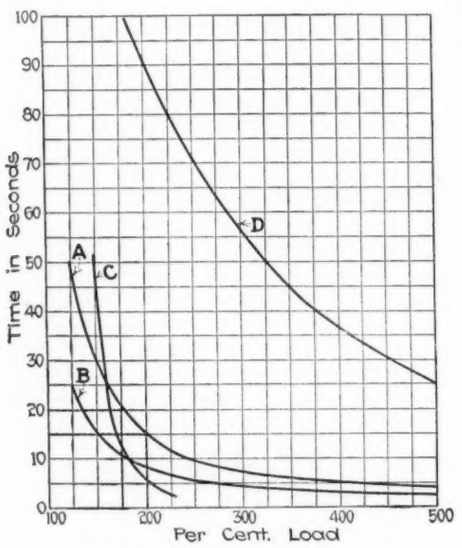


FIG. 1. CHARACTERISTIC CURVES OF MOTOR PROTECTING DEVICES

If one line or phase to either of these two types of motors breaks, or a fuse blows, or for any reason open-circuits, the motor will continue to run on single-phase power, provided the torque does not exceed the single-phase torque, but with an increased current in the remaining single-phase circuit. This current will be approximately 175 amperes for either motor of 40-hp. capacity when driving full load. Since the heating of the motor varies approximately as the square of the current, the three-phase motor will have to dissipate about three times and the two-phase motor about four times the heat per phase that they would have if they continued under multiphase or normal condition. This explains why polyphase induction motors burn out if they are operated single-phase when driving approximately full load.

There are several methods employed to disconnect the motor from the line when one of the phases fails. The most common means used is two inverse time-limit overload relays per motor, which control a line contactor. To get the best protection from this type of relay, it should be calibrated with the dashpot removed on a current about 10 per cent. higher than that required to drive the load. This adjustment should then never be changed. With the dashpot and oil replaced, the oil vents should be adjusted so that the relay will not function during starting; that is, the plunger should not be allowed to rise so high that it will not return after the motor has fully accelerated. If later, the relay does completely function during starting, owing to its parts wearing or for any other cause, the oil vents should be decreased, but the current adjustments should never be changed.

With this means of protection a motor is protected against ordinary overloads above 10 per cent. and also against overloads in any of the phases caused by a single-phase action. If the motor is running light or has only a partial load on single-phase power, such that it would not require 110 per cent. current, the motor will not overheat and the relays will not function, which is a satisfactory condition. Of course the relays should be in both the starting and the running circuit, unless the equipment is hand-operated and the operator can be relied upon to take the needed precautions, so that if the motor did not start with the single-phase power, the relays would permanently disconnect it.

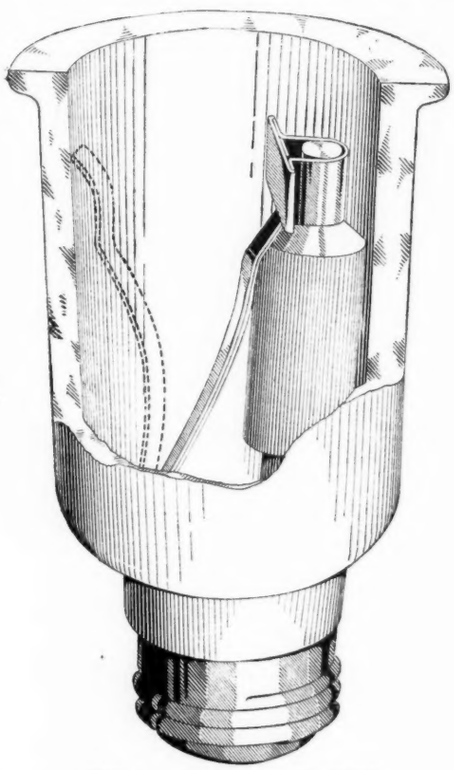


FIG. 2. PROTECTIVE PLUG

Fig. 1 shows two typical curves of an inverse time-limit overload relay which was set to trip on 110 per cent. full-load current, as already described, and set with two different adjustments of the oil vents. Curve *A* shows the time-current conditions with a small vent, and curve *B* with a larger oil-vent adjustment.

Suppose the two 40-hp. induction motors were equipped with two of this type of relay per motor, those for the three-phase motor being calibrated to trip on 110 amperes and those for the two-phase motor on 96 amperes (110 per cent. of full-load current) and the dashpot on each was adjusted as shown in Fig. 1, curve *A*. If these two motors were running and each driving a full load and one of the phases on each motor should open circuit, each would require approximately 175 amperes, as previously explained, to keep them running. Since 175 amperes represents 175 per cent. of full load or rated current for the three-phase motor and 200 per cent. for the two-phase motor, the three-phase motor will be disconnected from the line, as per Fig. 1, curve *A*, in 20 sec., and the two-phase motor in 15 sec., as indicated by the dotted lines. If the dashpots were adjusted as shown in curve *B*, the three-phase motor would be disconnected in 11 sec. and the two-phase motor in 8 sec. If the dashpots were calibrated with a smaller oil vent than as represented in curve *A*, the time required to disconnect the motors would be proportionately longer. Therefore, since these motors will not become damaged in this time with 175 amperes per phase, the relays will give adequate protection.

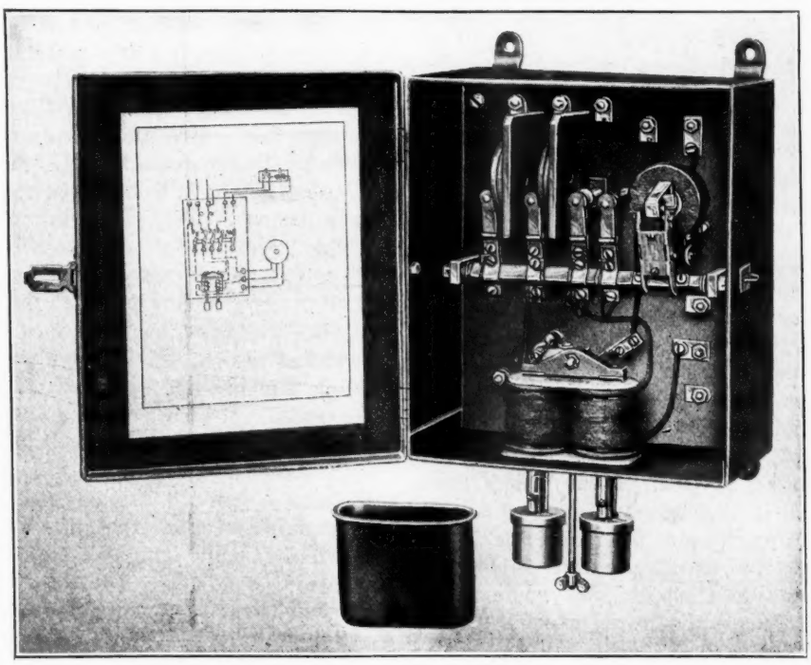


FIG. 3. CONTROLLER EQUIPPED WITH TWO INVERSE TIME-LIMIT RELAYS

A number of instances have happened where motors that have had this type of relay for protection have burned out. In every case the cause could be traced to one of two reasons and sometimes both. When the relay leaves the factory, it has the current adjustment correctly set for a specified motor. When the relays are actually applied, they may or may not be for a motor of the same rating and also the adjustment may have been changed. In other words, the current adjustment is not correct; namely, 110 per cent. of the motor's current rating.

The second reason is that the application is wrong. If a squirrel-cage induction motor is connected to a heavy-inertia load such that it takes five or six times rated current for 10 or 15 sec. or longer to accelerate it, the dashpot on the relay cannot prevent the plunger from pulling up and opening the relay contacts unless the oil vents are completely closed, and this will prevent a reasonable overload from opening the relay contacts in the required time.. For a case of this kind special means must be employed which will give the same protection to the motor as described in the foregoing. However, if the current adjustment is correctly set and the dashpot is capable of giving the required time retardation during the starting period without completely closing the oil vents, a motor need never burn out from overloads or from a single-phase condition when protected with two inverse time-limit relays.

The second means employed for protecting the motor is a standard fuse in each of the phases. A fuse also has an inverse time characteristic, as shown in Fig. 1, curve *C*, but this is fixed and cannot be adjusted to suit conditions. Curve *C* is for an average size of fuse, a large size taking a longer time to open and a small size a shorter time. This type of fuse will blow with 110 per cent. of its current rating after several minutes. If a 100-ampere fuse were applied on the three-phase and an 87-ampere fuse on the two-phase motor specified in the foregoing, the three-phase motor would blow its fuses, under the previously described condition, in 12 sec. and the two-phase motor in 5 sec. as shown in curve *C*, Fig. 1. This curve shows that the motor would have to start very quickly to prevent the fuses blowing during the starting period. The third means employed for protecting the motor is a protective plug, Fig. 2, which has a much longer time characteristic than a fuse. Curves *C* and *D*, Fig. 1, show this difference in time. If applied as stated, the three-phase motor plugs would open in 110 sec. and the two-phase motor plugs in 93 sec. This current-time characteristic approaches the thermal or heating characteristics of the motor and for that reason a plug can be used having the same current rating as the motor. This will allow the motor to start an average load without opening the plug and will also protect the motor against an overload from either a phase failure or an ordinary overload on the motor.

The fourth means employed for protecting the motor is a phase-failure relay which controls a line contactor. This relay allows the line contactor to be closed and opened when the power supply is normal, but if any phase fails with the motor running, the relay will instantaneously open the contactor and remain thus until reset by hand. This relay has the advantage that no adjustment is required to meet a starting condition and therefore it will always protect the motor against single-phase operation, but it also has the disadvantage

that it will not protect the motor from ordinary overloads. This condition must be taken care of by one of the means described, which should also take care of a harmful single-phase condition.

A simple and compact automatic starter combining a line contactor *C* and two inverse time-limit overload relays *R* for throwing small squirrel-cage induction motors on the line is shown in Fig. 3. The line contactor is governed by means of a "start and stop" push-button station in series with the overload relays.

These relays, if calibrated as explained in the foregoing, will give all the protection needed to a motor unless it is driving a heavy inertia load which it must also start.

Economical Operation Must Be Made Certain

By H. S. RICH

The author demonstrates that operating methods should be carefully scrutinized or economies of construction and new business campaigns will go for naught.

THE big items and the important business propositions in many plants seem to be all that the manager and superintendent have time to consider; that is, how more business can be handled, how more raw material can be purchased and stored, how enough help can be procured, how profits can be increased, and how the plant can be enlarged. In short the attention and study of executives seem to be in many instances entirely given to the opening up of new and wider avenues of increased business, whereas the investigation and curtailment of losses and leakages get little attention.

With increased business on one hand there are often increased losses on the other hand, a situation which does not spell economy of operation. For instance, in one large plant more than $250,000 was spent in one summer for new buildings, motors, machinery and various other equipment which necessitated new switchboards and cables being installed in the plant's power house. Of course, all this expense was recalled to mind many times at the foremen's meetings, with the request that labor should be hired as cheaply as possible, more work be turned out with less help, and less waste of time tolerated to counterbalance the heavy expenditures of the plant extensions.

This was good advice when looked at from the official position, but the trouble was not at that end of the business. The great weakness was very evidently along the line of losses, wastefulness and leakages.

Real Opportunities for Economy

In this plant was operated a large woodworking shop, and the sawdust, plank ends and blocks were sold to anybody and everybody for 25 cents per 100 lb. (45 kg.). The receipts were often commented upon as being a good rebate on the original costs. Then when any employee wished to purchase leather for shoes, glass for a window or a casting these supplies were sold at cost price, whereas the cost of the clerk's time, the ink and paper and the cashier's time in making out receipts were not charged for. Thus these transactions amounted, in a year, to a larger deficit.

The new manager and superintendent increased the profits of the plant by eliminating these losses in a short time. The sawdust and blocks were not sold but were burned in the boiler house. The firemen complained about mixing coal with so much wood and sawdust, but they were told that it had to be done. It was done, and the coal pile was saved about 25 per cent. daily and thus the season's supply was extended. The firemen's pay was increased 10 per cent. as 2½ lb. of sawdust and wood was required to equal 1 lb. of coal. The sale of supplies to employees was stopped entirely, thus saving a considerable overhead expense.

The next matter of waste was the city water. The last bills were studied, and it was concluded that too much good clean water was being used for sprinkling, washing and uses other than drinking. A piping system was immediately installed by the company's steamfitters through the entire plant and supplied by a fair-sized pump in the fire pump house by the river, whence water was forced to all toilets, forge tubs, foundry hoses and wash basins.

This resulted in the purchase of only 25 per cent. of the original water supply for drinking fountains having small inverted spring faucets of limited flow. Thus the city bill was curtailed, and the over-all saving was apparent at the end of the year even though the cost of piping, supplies and help cost was high. All pipe ends were used up, straps were made and none purchased, and small-sized piping was used wherever possible. Even the river water was not supplied anywhere in wasteful amounts. The forge-shop cooling tanks were not running over all the time but filled when needed, and the hydraulic lifts and elevators were restricted to necessary usage only. The force pump was thus slowed down and kept so through the entire year, with much saving of steam.

One Generator Does the Work of Two

The used electrical energy offered another large opportunity for saving by lowering the peak and average demand. In the first place, all carbon lamps were replaced with tungsten, thus saving where possible the difference between 3.5 watts per candlepower and 1.25 watts, the specific consumption of carbon and tungsten lamps respectively. For the general lighting of small areas high-candlepower tungsten lamps were used, and for larger areas, such as foundry floors, forge shops and showrooms, the large sizes of nitrogen lamps were found to be the most economical.

All general and bench lighting was supplied with switches in locked steel boxes, and each foreman was responsible for excessive use of electricity. All drop lights were equipped with locked guards to prevent the removal of the valuable lamps. No lights except those actually in use were allowed to burn during the noontime, and during other hours if a machine was idle its light had to be shut off as well as the power, oil and air supply.

The reduction in the use of electricity was very evident on the switchboard ammeters, and during the summer a 100-hp. engine with its generator was usually shut down about 9 in the forenoon, whereas formerly it had been run until noon to supply the load. Thus steam, oil and wear and tear on the two machines were saved, and the life of many lamps was substantially extended.

Stopping the Small Leaks

The supply of cotton waste was cut down from 10 lb. (4.5 kg.) per department to 5 lb. (2.25 kg.), and even to 2 lb. (0.9 kg.) for certain fairly clean work, as it was found that much waste was thrown into rubbish when only slightly soiled. The shop porter or janitor had orders to destroy only the worst of the waste, and to return to the foreman any that was but slightly soiled. This caused some grumbling, but when it was found difficult to get new waste the old proved very acceptable.

Motors Should Not Run Idle

The electric power was reduced by shutting off all motors not likely to be needed for at least fifteen minutes. Electric elevators were not operated for foot passengers except with loads. One large forge shop had a new four-wire power line run from its power house to a 50-hp. motor, as the old line had caused such a drop in voltage, due to its small size, that five men were needed every morning and noon to help start the large power pulley with a long hooked pole, a task which often took ten minutes or more.

A big item of electrical power is the proper arrangement of alternating-current motors; that is, using a large one only where actually needed, but using small sizes where they are large enough, thus avoiding the use of a large motor to do light work, which lowers the power factor and requires excessive generator capacity.

The matter of wasting steam heat was taken up very seriously in one large factory, and it was satisfactorily settled by having the foremen maintain a comfortable temperature in the departments, using as little steam as possible and not keeping the radiators wide open all day long, thus compelling employees to open the windows to avoid the excessively warm air. One thermometer placed at each end of a large room helps to maintain an even temperature. Where employees are more or less inactive a higher temperature is required than when they are laboriously employed, in which case they demand more fresh air and less heat.

Negligence of Co-Employee

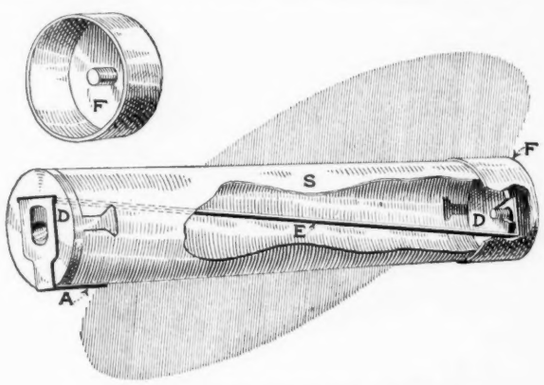
It is the law in Georgia, as in several other states, that an employer is not liable for injury to an employee resulting from negligence of a fellow servant engaged in the same general line of work. This rule has been applied by the Court of Appeals in that state to a case where the plaintiff, a fireman in a steam-power plant, was injured while repairing inside of a boiler. (Parham vs. Berryton Mills, 98 Southeastern Reporter, 241.)

The plaintiff was directed by his superior to make the repairs. While he was so engaged, another fireman, under orders from the same superior, fired an adjacent boiler that was connected with the one in which the plaintiff was working and permitted steam to escape into the latter boiler.

"What was the proximate cause of the injury received by Parham?" asks the court. "It cannot be said that the order from the vice principal and the entering of the boiler at the time by Parham was negligence, for at that time there was no steam in the boiler and there was nothing dangerous about the task. Was not the proximate cause of the injury the act of Alexander (the other fireman), the fellow servant, in opening the valve on the boiler which had steam in it, or the leaving open of the valve on the boiler in which Parham was working? If either be true, and this is the negligence relied upon, it seems to us that the case is controlled by the rule laid down in Civil Code 1910, Sec. 3129, that 'Except in cases of railroad companies the latter is not liable to one servant for injuries arising from the negligence or misconduct of other servants about the same business.'"

Another Type of Refillable Fuse

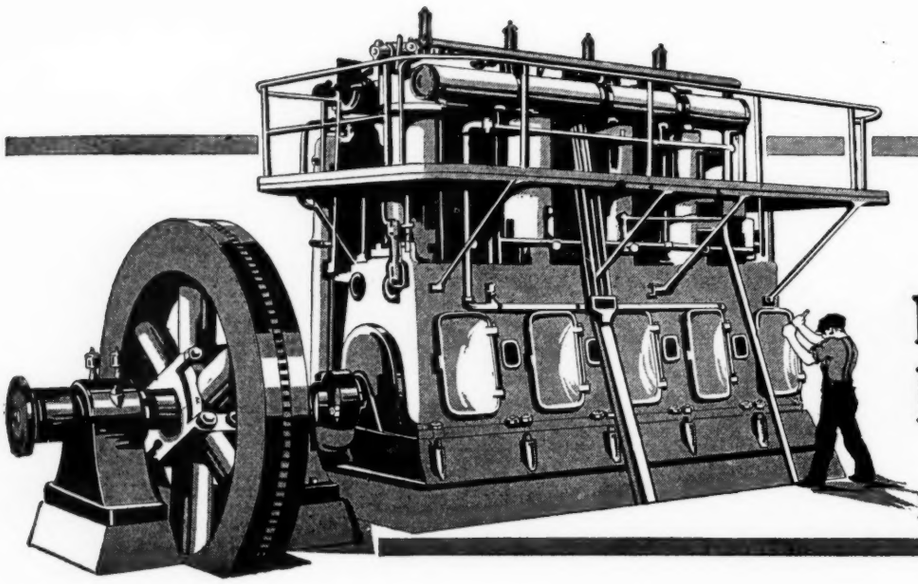
A few years ago refillable fuses were a novelty; now they are almost as common as the nonrefillable type. The illustration shows a type of cartridge refillable fuse known as the Volk, recently placed on the market by the Volk Distributors, New York City. This fuse is made up of a fiber shell *S* closed at each end, by metal disks *D* held by two dovetails that pass through the



SECTIONAL VIEW OF REFILLABLE FUSE

fiber shell as shown. The fuse element *E* is made up in strips of standard form and passed through slots in the metal disks at each end of the shell. After placing the fuse element through the shell, the ends are bent over and the ferrules *F* screwed on, making a firm contact between the ferrules and the fuse element. This fuse has only two removable parts—the ferrules. Up to 60-ampere capacity the ferrules have a machine screw brazed in their center, which threads into the metal disks *D* on the end of the shell. In sizes above 60 ampere capacity knife terminals are used. In this size the ferrules are held in place by two screws threaded into the metal disks *D*. One end of the fuse metal is made long enough to extend beyond the ferrule, as indicated at *A*. On this end is marked the capacity of the fuse element, so that the inspector may see at a glance how the circuit is fused.

An aluminum alloy containing 10 per cent. of calcium is reported to possess valuable properties. It is lighter than aluminum, easily melted, and machines satisfactorily. It surpasses alloys of copper, tin or zinc with aluminum in its resistance to corrosion, is not brittle, and when cast it conforms to all the details of the mold.



Talks on DIESEL Engines

by L. H. Morrison

XIV—The supplying of high-pressure air for the injection of the fuel charges furnishes a subject of the evening's talk, and air-bottle explosions are touched upon.

"WE'LL look into the subject of air compression and injection this evening," Egan announced when the class had assembled. "We could spend a lot of time if we took up air-compressor construction; but we are interested particularly in operation and the troubles that arise.

"There are three ways of driving a compressor—by direct connection, by belt from the engine, and by a separate motor. It is a very common practice to mount the air compressor on the engine frame and drive it by means of a drag crank on the engine shaft. Such a compact drive is advantageous in motor ships or submarines and in other places where lack of floor space prevents the use of a separate compressor. However, an engine room is seldom so confined. In my opinion it's not a good idea to make the entire engine unit so compact. If anything goes wrong with the compressor, the engine must be stopped until repairs are made. Take the case of our plant here. If all the engines were equipped with direct-connected compressors, on peak loads we would frequently be up against it, for it's always at such times that a compressor valve breaks. As it is, we can disconnect the compressor connecting-rod in a few minutes and cut in the air line from the motor-driven compressor. If all were separate, no delay would occur; merely changing from one compressor to another would keep the engines going.

"On the vertical engine there isn't a great deal of room to work in around the compressor. So I often fear it's neglected. With the horizontal engine the direct-connected compressor is fairly accessible. Where no high-pressure air bottles are used, the short distance from compressor to needle valve allows the engine to begin to fire quicker than with a belted compressor."

"I don't quite get that, chief," Kelly broke in. "I thought all engines had to have air bottles or tanks."

"That is a perfectly natural supposition on your part, Kelly, since all our engines use bottles. However, quite a number of engines use no bottles. They are generally of small horsepower per cylinder, and the scheme is to let the air go direct from the compressor to the injection valve, with no air reservoir in the line.

"This type uses a relief cam that relieves the compression so that low-pressure air may be used in starting. The engine is turned over several times by the low-pressure air. By this time the air compressor has built up the pressure in the air-injection line to around 600 lb. The injection-valve cam is then thrown into action, and the engine fires.

"With most vertical engines no compression relief is used. It requires high-pressure air to turn the engine over against the compression and the friction load, and it would be impossible to use low-pressure air to do this. So it's necessary to have bottles, at least for starting."

"Why not cut them out when running?" Woods inquired.

"A simple answer might be that since the bottles were there, they might as well be open on the line when running," rejoined Egan; "but that is hardly a legitimate reason. Consider an engine in operation, with the compressor delivering all the air required at a particular load, and the suction control valve set so that no excess air is drawn into the compressor to be later blown from the relief valve. Now suppose that a heavy load comes on. The air discharged by the compressor into the air line is the same as before. The heavy fuel charge which the fuel pump has just deposited in the atomizer calls for a higher air pressure to thoroughly atomize it. Most atomizers are designed on the theory that the air pressure will build up behind the heavy fuel charge, and thus proper atomization is secured; but

In the next article, the lubrication of crankshaft bearings, crankpins, piston pins, pistons and helical gears will form the subject for the evening's discussion.

this building up cannot take place when there is no reservoir of air to build up the pressure. Without bottles, there is but a small amount of air between compressor and nozzle and the compressor has completed its stroke before the nozzle opens. Consequently, there is no storage to draw on. Of course the operator can regulate the compressor suction and thus secure a higher pressure, but this can only care for the load changes that are of some permanence. From my viewpoint the air bottle is desirable."

"Well, chief, if some engines don't use air bottles, where do they get the air to start with?"

"It isn't necessary to use high pressure to start with, Kelly, if the engine has a compression relief arrangement. So the starting air in these engines is about 250 lb. pressure. This air is taken from the compressor when the engine is running and stored in the low-pressure starting tanks. The air compressor is always large enough to supply the atomizer and to charge the tanks."

"What about air-bottle explosions?" Woods asked. "The other day a belting salesman was telling us of an explosion he witnessed a year or so ago."

"I guess that was Jones," said Egan. "The explosion occurred at the Fremont plant. I happened to be there and saw Jones do a hundred yards in less than ten seconds. Three bottles gave way, and one of them

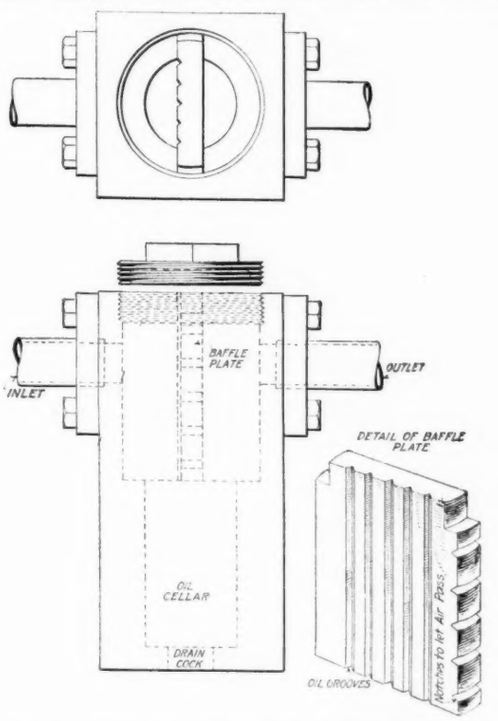


FIG. 1. DETAILS OF OIL TRAP FOR AIR LINE

shot across two blocks. It was pure luck that no one was hurt."

"What causes those explosions, J. R.?"

"Well, Woods, to my way of thinking it's due to cylinder oil. This oil will gradually collect in the air line and bottles, and if conditions are just right, the oil will ignite. The majority of air compressors, operating with 1000 lb. pressure, are insufficiently cooled, especially in the matter of an aftercooler. Frequently the air leaves the compressor with a temperature above 200 deg. F. This heat rapidly vaporizes the oil trapped in the bottles and ignites it. There is no doubt that every compressor should have an aftercooler to reduce the temperature of the air as it leaves the high-pressure cylinder. Furthermore, when bottles are used, the air line should have an oil trap.

"The traps we have here were made right in our own shop. I never could induce the big chiefs to buy them, so I figured out a scheme and made them. You all know how they look outside. This sketch (Fig. 1) gives the details. I simply took a piece of square machinery steel, machined both sides and made pipe connections. Then I bored the vertical hole, making it of two diameters as shown, tapping the top for a plug and the bottom for a drain. Next I machined a flat strip of steel, notching the side edges and cutting several grooves in the face toward the inlet. This strip was inserted in the vertical cavity. The air, as it enters the block, must pass around this partition to get out, and so the oil is thrown against the plate and trickles down the grooves to the bottom, where it's drained out every day. It's well to remember that some of the oil used in the compressor will vaporize and pass out with the air. Then if the high-pressure air is not passed through an aftercooler, some of the oil vapor will be carried into the bottles, where it will cool and liquefy. The separator cannot eliminate oil in a gaseous condition. Therefore, two things are necessary to prevent explosions—an aftercooling of the air and a good separator."

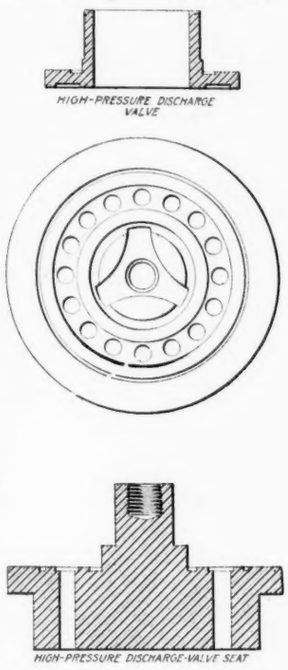


FIG. 2. DISK TYPE OF DISCHARGE VALVE

"Mr. Egan," said Woods, "I've heard that it was a good idea to have the air charge hot. Is that right?"

"There is one time when it would seem right to use hot injection air—that is, on very heavy loads. On low loads the entire engine cools off. The water jacket, since it absorbs practically the same amount of heat, actually absorbs a larger percentage of the heat than on full load. So the compression charge in the engine cylinder doesn't reach as high a temperature. If the load is very small, the temperature may be too low to ignite the oil. This is aggravated by the chilling effect of the injection air."

"How's that, chief? I can't see how the air would chill the combustion chamber."

"Well, consider the facts. The charge of fuel in the fuel valve is small. There is nothing to prevent the air from blowing direct into the cylinder. In blowing through the nozzle in a practically unbroken stream, the air expands and, in so doing, becomes comparatively cold. This has a chilling effect on the fuel charge and tends also to lower the temperature of the entire

charge of compressed air in the engine cylinder. Under such conditions, an engine will probably misfire and have a smoky exhaust. If we could raise the temperature of the air-injection charge, the chilling effect would be eliminated, or at least reduced."

"How about full load, J. R.?" Kelly inquired.

"On full load the air should not be hot. First, there is a danger of getting the oil hot, and if it is a gas oil, it may explode in the fuel-valve cavity. Again, hot air has a larger volume than cold air under equal pressure, which means that it requires more work to compress a given weight of hot air than of cold air. This causes excessive compressor work or too small a weight of air injected. I'll choose having the air charge not above 120 deg. F. One thing the majority of builders neglect is to provide enough coils in the aftercooler."

"How about the amount of compressor-cylinder oil?" The Scotsman asked the question.

"The amount of oil to be used in the compressor varies with different engines. A fair estimate with a three-stage compressor is about these values: One drop per minute to the low-pressure cylinder, one drop per minute to the intermediate-pressure cylinder, and five drops per minute to the high-pressure cylinder."

"Why do you feed more oil to the high-pressure than to the low-pressure cylinder? The low pressure is lots

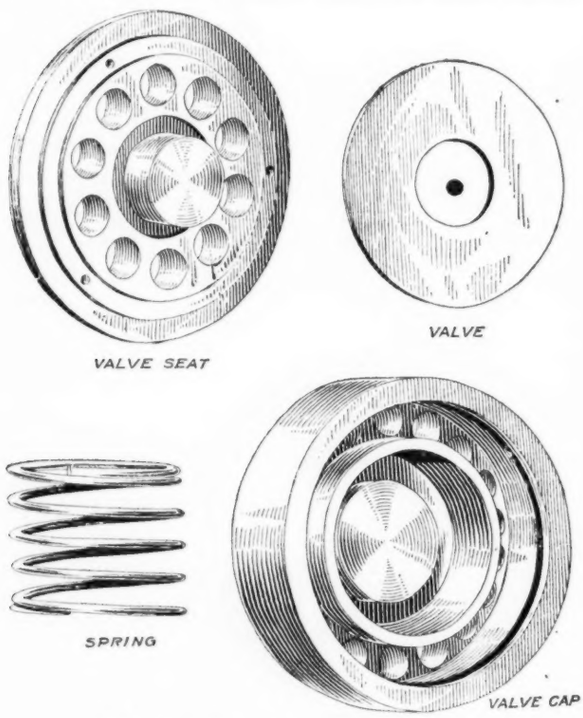


FIG. 3. DETAILS OF POPPET VALVE

the biggest, and I'd think it ought to have a lot more oil." Woods raised this objection.

"The low-pressure cylinder is working against very low pressure, and the temperature in the cylinder is very low. No oil is vaporized, and all is used in lubricating only. When we get to the high-pressure, we find the temperature in the cylinder is high and the oil will vaporize to some extent. It's necessary to provide for this, and at the same time to have a good film of oil on the piston to prevent sticking. One thing, boys, don't be too generous with oil. Never use any more than just enough. Also, be sure that the wear on the connecting-rod brasses doesn't let the piston clearance become too great. A considerable loss in compressor efficiency can occur with only a few thousandths wear on the brasses."

"Chief, how about the valves? Do you like the plug-hat kind or the flat round one?"

"By the flat round one, Kelly, I suppose you mean the disk valve shown in Fig. 2. This is fine for a slow-

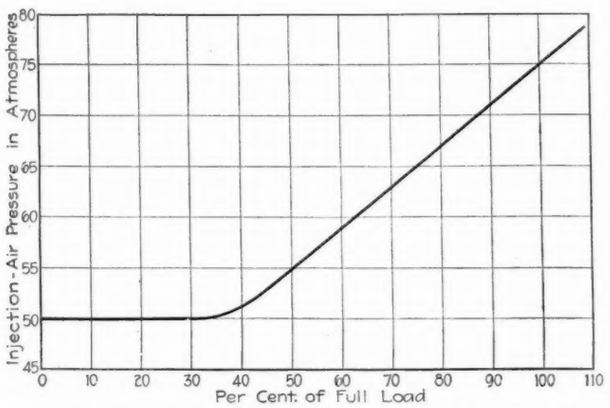


FIG. 4. RELATION OF INJECTION-AIR PRESSURE TO LOAD ON ENGINE

speed compressor; but if the speed is above 150 revolutions, it tends to bend at the edges rather than rise, which in time causes the disk to crack. It is just as good as most valves.

"Fig. 3 is a plug-hat or poppet valve. This sketch shows the valve seat and cage as well. Its chief difficulty is the tendency for the brim, as you'd call it, to break away from the crown. In several makes of engines using this type of valve, the same trouble occurs. We have tried all kinds of steel for the valves—nickel steel, high-speed tool steel, machinery steel and what not. The best kind I've found is vanadium steel carefully oil-treated. It seems to have the necessary strength and is tough.

"When grinding compressor valves, use more than good care. Use only the finest of rotten-stone. Even emery is too coarse for so delicate a valve seat. Also, test the relief valve on the intercooler every month to see that it doesn't stick. Now, boys, is there anything you want to ask?"

"Well, J. R.," Woods spoke up, "what injection-air pressure ought we to carry?"

"Practically all engines operate to best advantage with approximately the same pressures. The blueprint (Fig. 4) hanging on the wall gives a curve that shows the pressures to be carried at various loads on our engines. I like to see this followed as close as possible since the values have been tried out and are about right."

It is reported that ten of the largest locomotives in the world are to be built for the Virginian R.R. Each weighs 449 tons with the tender, has a high-pressure cylinder 30 in. in diameter, low-pressure cylinder 48 in. in diameter, and is equipped with 20 driving wheels. Each locomotive develops 5040 horsepower.

Finish the job with the Victory Liberty Notes.

Comparison of the New A. S. M. E. Boiler Code and the Massachusetts Boiler Rules

IN THIS article an attempt will be made to point out the chief differences between the rules of the new A. S. M. E. Code and those of the State of Massachusetts, for the construction of boilers. A direct comparison is difficult in some respects, owing to the fact that the Massachusetts rules are divided into three parts, the first and second affecting old boilers and the second and third, new boilers. There is no clear-cut division between power boilers and heating boilers in the Massachusetts rules, as is the case with the Code. In fact, heating boilers are almost entirely neglected in the Massachusetts rules. No attention will be given to the rules for old boilers as provided for in either set of rules, and heating boilers, as treated in the Code, will not be particularly referred to.

A feature that makes reference to the Massachusetts rules cumbersome is the method of dividing them into parts and sections, the paragraphs in each section being numbered consecutively, beginning with 1 each time. In the Code the paragraphs are numbered in order throughout the book. In an attempt to overcome the difficulty of referring to the Massachusetts rules, the references will be given in the following manner: After the letter M there will be given the page and paragraph numbers; thus, M-51-6 will refer to page 51 and the sixth paragraph on that page of the 1918 edition of the Massachusetts rules. The references to the Code will be the letter C followed by the paragraph number referred to; thus, C-51 indicates that paragraph 51 of the Code is referred to.

Cast iron is evidently intended to be prohibited as a material for the construction of steam boilers to be operated at pressures in excess of fifteen pounds, except for headers, cross-boxes and such parts, by either set of rules. The Massachusetts rules distinctly state this to be a fact (M-10-1), but the Code does not clearly bring out this point. In fact, from C-9 it would appear that a cast-iron boiler might be constructed under the Code rules for any pressure up to 160 lb. The Massachusetts rules permit the use of cast-iron mud drums for boilers up to 160 lb. pressure (M-51-7), while the Code requires all such drums, except those on heating boilers, to be of wrought or cast steel (C-10). The shearing strength allowable for rivets under the Massachusetts rules (M-10-5) is less than in the Code, except for iron rivets in single shear. The minimum safety-valve capacity required under the Massachusetts rules is based on the working pressure and the grate area to be served (M-13-2).

While the Massachusetts rules indicate that when conditions exceed those on which the table for safety-valve capacities are based, a formula must be used, given in M-18-4, to determine the valve capacity required, there is no very definite relation between the amount of steam to be handled and the discharge capacity of the valve, to determine when the formula must be applied. The particular condition that may be exceeded is in regard to the amount of water that may be evaporated per square foot of grate surface per second. The formulas given are based on an assumed discharge area, equivalent to one-eighth the nominal valve area for flat-seated valves and one-eleventh the nominal valve area for bevel-seated valves, without regard to what the actual lift may be.

This leaves the matter entirely to the judgment of the inspector with no very definite means to determine when it is necessary to depart from the values given in the table. It is likely that no two inspectors, except at a joint inspection, could agree on the proper procedure in a given case.

The Code minimum requirements for safety valves are based on the heating surface to be served (C-274) and the further requirement that the rise in pressure above the maximum allowable working pressure shall not be more than 6 per cent. (C-270). The Massachusetts rules limit the diameter of safety valves to a maximum of 5 inches (M-19-9), while the Code has no such limit. The Massachusetts rules (M-19-9) require that a lifting gear for safety valves be supplied, which will lift the valve from its seat one-eighth the diameter of the valve when the pressure under the valve is 75 per cent. of the pressure at which it is set. The Code requirements for lifting gear for safety valves is that it must be capable of lifting the valve from its seat one-sixteenth of an inch when there is no pressure on the valve (C-282).

Fusible plugs are required by law in Massachusetts (M-19-10), but their use is optional so far as the Code rules are concerned (C-428). The Massachusetts rules specify that check valves must be supplied on the return pipes to heating boilers (M-25-24 and M-25-25), while the Code has no specific requirements for such fittings on the return pipes to heating boilers. The limit for the hydrostatic pressure test in the Massachusetts rules (M-28-1) is given as 1¼ to 1½ times the maximum allowable working pressure; in the Code (C-329), 1½ times the working pressure is required with an upset limit of not over 6 per cent. above this amount.

The material specifications as given in the Massachusetts rules are very meager as compared with the Code. The Massachusetts rules specify two grades of steel for shells, etc.—"firebox" and "extra-soft." The only difference in the chemical characteristics specified for firebox steel as given in the Code (C-25) and the Massachusetts rules (M-41-3), is that for such steel made by the basic process the phosphorus content may be 0.005 per cent. more in the case of the Code than for the Massachusetts rules. This difference, however, has been removed by a ruling of the Massachusetts authorities issued Dec. 2, 1918, making this requirement the same as the Code. There is no extra-soft grade of steel specified in the Code rules, although a steel of lower tensile strength than either flange or firebox may be used as provided for in C-28.

In the Massachusetts rules rivets are specified to be made of extra-soft steel (M-42-4); the rivet material required by the Code (C-41) differs from this in chemical characteristics only in that the sulphur content may be 0.045 per cent. instead of 0.04 per cent., as required by the Massachusetts rules. The physical characteristics for steel plate as given in M-42-5 and C-28 differ slightly as regard to tensile-strength range and the requirements for elongation.

The bend test for material over three-fourths of an inch in thickness as called for in the Massachusetts rules (M-43-7), is different for similar tests required for the same material under the Code rules (C-30). The specifications for cast iron and cast steel given in the Massachusetts rules (M-50-4 and M-50-5) merely refer to the ultimate strength of the material, while the specifications for such material in the Code rules are very complete. However, M-88-53a specifies that steel castings must conform to Class B grade of the American Society for Testing Materials. A specification for the physical characteristics of stay-bolt material is given in the Massachusetts rules (M-79-36), but it is not required that such material be used for stay-bolts unless certain special stress allowances are desired.

No specifications for tubes or tube material are given in the Massachusetts rules, while the Code (C-20-21 and 22, also C-164 to 178) goes into the subject in a very complete manner. The efficiency of ligaments between the tube holes that may be placed in the shell of the drum of a boiler as given in the Massachusetts rules (M-58-3) is different from those required in the Code rules (C-193). The Massachusetts rules do not permit a longitudinal joint over twelve feet long on the shell of a horizontal-tubular boiler, vertical-tubular boiler or a locomotive-type boiler (M-62-9); the Code specifies this restriction only for longitudinal joints on the horizontal-tubular type of boiler and where the joint is of the lap type; butt joints of any length may be used if the material is tested in the direction of maximum stress (C-190).

The required thickness for butt straps for plates of different thicknesses are the same in both sets of rules with the single exception that for 1-in. plate the Code requires $\frac{11}{16}$-in. straps and the Massachusetts rules $\frac{3}{4}$-in. straps for this plate thickness (C-19 and M-63-13). The pressures allowed on dished heads are different, the requirements for such heads being given at C-195 and M-64-16. The pitches allowed for stay-bolts on flat surfaces are different in the two sets of rules, although not radically so; the requirements are given at M-66-21, M-68-22, M-69-23 and C-199, C-204.

In determining the area on the segment of a head to be stayed, the Massachusetts rules deduct the area between the bounding surface and lines drawn two inches above the tubes and three inches from the shell (M-72-28). The Code specifies the fixed distance of two inches above the tubes in making such calculations, but varies the distance allowed from the shell, depending on the thickness of the head, the radius of the turn of the flange and the pressure for which the boiler is constructed (C-214). The stresses allowed on stays by the Code rules (see Table 5 on page 59) are somewhat higher than the corresponding stresses allowed by the Massachusetts rules (M-78-35). However, considering that the Code specifies the quality of the material permitted to be used for such purpose, the difference in this respect between the two sets of rules is not of moment so far as safety is concerned. In the Massachusetts rules where hollow stays are used, if the hole in the stay is not over $\frac{3}{16}$ in. in diameter, the bolts are considered as solid for the purpose of calculating their strength (refer to part of paragraph 39 at top of page 83 in the Massachusetts rules). In the Code the net cross-sectional area is to be used in all such cases (C-220).

The Massachusetts rules require a manhole below the tubes in horizontal-tubular boilers only when the diameter is 60 in. or more (M-89-60); the Code requires such openings in boilers of this type when the diameter is 48 in. or over (C-264).

The Massachusetts rules do not allow an internal pipe to be fitted to a connection to which a safety valve is attached (M-92-1). The Code permits such internal pipes with certain restrictions (C-290).

The Massachusetts rules require that a safety valve be applied to a superheater if it can be shut off from the boiler to which it is attached, and that such safety valve be placed near the inlet to the superheater (M-93-2). The Code rules require a safety valve on all superheaters, and this valve must be located near the outlet from the superheater (C-288).

Main outlet valves must be extra-heavy by the Massachusetts rules when the working pressure is over 100 lb. (M-93-4); the Code rules have a similar requirement, but specify the limiting pressure as 125 lb. (C-302). Two valves or a valve and a cock must be applied to the blowoff connection, under the Massachusetts rules, when the pressure is over 100 lb. (M-96-18); the pressure limit for similar requirements under the Code rules is 125 lb. (C-311).

The Massachusetts rules do not allow the use of automatic water gages under any circumstances (M-98-27), while such fittings are permitted under the Code rules if constructed to comply with certain requirements (C-292 and C-427). The ogee construction at the bottom of the water-leg is prohibited by the Massachusetts rules (M-98-1), while the Code rules permit its use (C-13).

While the chief differences existing between the Massachusetts rules and those of the Boiler Code of the American Society of Mechanical Engineers have been given, in cases where both sets of rules treat the same details, the Code rules are evidently much more complete than are those of Massachusetts. This is, of course, not to the discredit of the Board of Boiler Rules of Massachusetts, for the Code Committee made complete use of the Massachusetts rules and many others in its attempt to make the Code rules comprehensive.

The Massachusetts rules are not only silent on the question of gage and material for boiler tubes, but lack any reference to flues or furnaces, except of the stay-bolted type as used in the vertical-tubular type of boiler. The question of braced and stayed surfaces is also not treated in a sufficiently broad manner in the Massachusetts rules, while the treatment of this subject in the Code is excellent. The treatment of safety valves is likewise too meager in the Massachusetts rules. While complete uniformity is desirable, considerable difficulty would be avoided for the inspector and the boiler manufacturer and a much wider and more competitive market for the purchase of boilers would be afforded the steam user in the State of Massachusetts if the two sets of rules could be harmonized with respect to the differences pointed out in this article.

Two things sought after in cooling-tower design are to present a large surface of water to the air and to provide for bringing constantly into contact with this surface the largest possible volume of new air with the least possible expenditure of energy.

They did not quit with four drives. We'll finish the Fifth Loan.

Proportioning Fuel Economizers

By A. B. CLARK

Shows how economizers may be proportioned to give desired gas and water temperatures. The data presented show the advantages of contraflow over parallel flow of water and gas.

As economizers are being used to a much greater extent than formerly, a discussion on the characteristics of this class of apparatus may be of interest. Assume that an economizer is to be so proportioned that the combined efficiency of both boiler and economizer will be 80 per cent., with a coal containing 10,000 B.t.u. per lb. The steam has a pressure of 250 lb., gage, and 250 deg. F. of superheat, the feed water entering the economizer at 100 deg. F. Under these conditions the heat contained in one pound of steam will be 1340 B.t.u. As the feed water contains 68 B.t.u., the heat given by boiler and economizer is 1272 B.t.u. per pound of steam. As the efficiency is 80 per cent., 8000 B.t.u. of the 10,000 B.t.u. in each pound of coal is used, and the evaporation is $8000 \div 1272 = 6.3$ lb. of water per pound of coal.

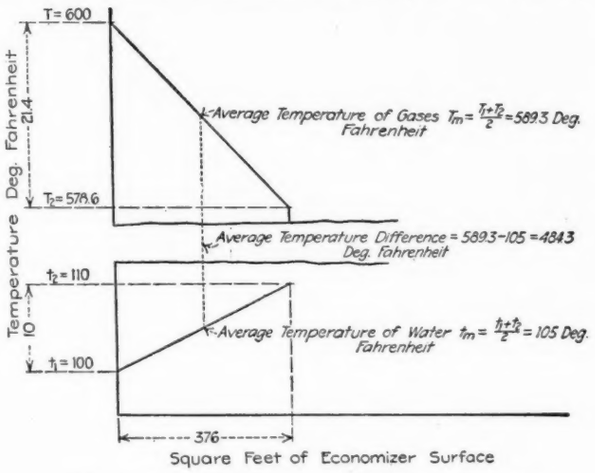


FIG. 1. GAS AND WATER TEMPERATURES IN PARALLEL-FLOW SYSTEM

Allowing for excess air and infiltration of air, there will be about 12.25 lb. of flue gases produced per pound of coal burned. Now, the heat given up by the flue gases must equal the heat absorbed by the water, if the radiation loss is neglected; that is, the product of the specific heat, weight and drop of temperature of the flue gases must equal the product of the specific heat, weight and rise of temperature of the water.

Let t_g represent the drop of temperature of the flue gases and t_w represent the rises of temperature of the water. Then

$$0.24 \times 12.25 \times t_g = 1 \times 6.3 \times t_w \text{ and } \frac{t_g}{t_w} = \frac{1 \times 6.3}{0.24 \times 12.25} = 2.14$$

This means that for every degree of increase of temperature of the 6.3 lb. of water the 12.25 lb. of flue gases will drop 2.14 deg. in temperature.

The weight of water passing through the economizer is taken to be 100,000 lb. per hour. It is assumed that the boiler is capable of evaporating this amount and that under these conditions the gas temperature leaving the boiler will be 600 deg. F. The water and gases may both flow in the same direction, called parallel flow, or in opposite directions, according to the so-called contraflow arrangement. The first consideration will be with the gases and the water flowing in the same direction, in which case the hottest gases meet the coldest water, as shown in Fig. 1.

TABLE I. · PARALLEL FLOW, WATER ENTERING AT 100 DEG. F.

T_1	T_2	t_m	t_1	t_2	t_m	$T_m - t_m$	H	100,000 × 10 B.t.u.	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	578.6	589.3	100	110	105	484.3	2,663	1,000,000	376	376
578.6	557.2	567.9	110	120	115	452.9	2,491	1,000,300	401	777
557.2	535.8	546.5	120	130	125	421.5	2,318	1,000,000	431	1,208
535.8	514.4	525.1	130	140	135	390.1	2,145	1,000,000	466	1,674
514.4	493.0	503.7	140	150	145	358.7	1,973	1,000,000	507	2,181
493.0	471.6	482.3	150	160	155	327.3	1,800	1,000,000	555	2,736
471.6	450.2	460.9	160	170	165	295.9	1,627	1,000,000	615	3,251
450.2	428.8	439.5	170	180	175	264.5	1,455	1,000,000	687	3,938
428.8	407.4	418.1	180	190	185	233.1	1,282	1,000,000	780	4,718
407.4	386.0	396.7	190	200	195	201.7	1,109	1,000,000	901	5,619
386.0	364.6	375.3	200	210	205	170.3	937	1,000,000	1,067	6,686
364.6	343.2	353.9	210	220	215	138.9	764	1,000,000	1,309	7,995
343.2	321.8	332.5	220	230	225	107.5	591	1,000,000	1,692	9,687

On examination of Fig. 1 it is easily seen that the average temperature difference between the water and gases for the part of the economizer under consideration is 484.3 deg. F. Tests made on a number of economizers show that the rate of heat transfer from gas to water is about 5.5 B.t.u. per square foot of surface per hour per degree temperature difference between

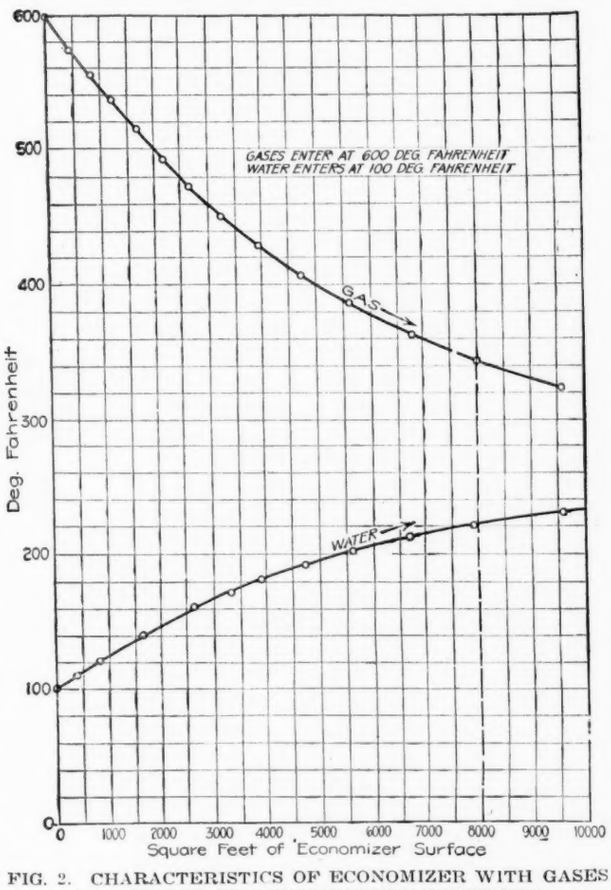


FIG. 2. CHARACTERISTICS OF ECONOMIZER WITH GASES AND WATER FLOWING IN SAME DIRECTION

the gases and the water, when the gas passage through the economizer is proportioned for a flow of 5000 lb. of gas per hour per square foot of area. It will be reduced to 4 B.t.u. per sq.ft. if the flow is reduced to 3000 lb. per hour and in proportion between these two points.

Using the higher value for calculation, it is found

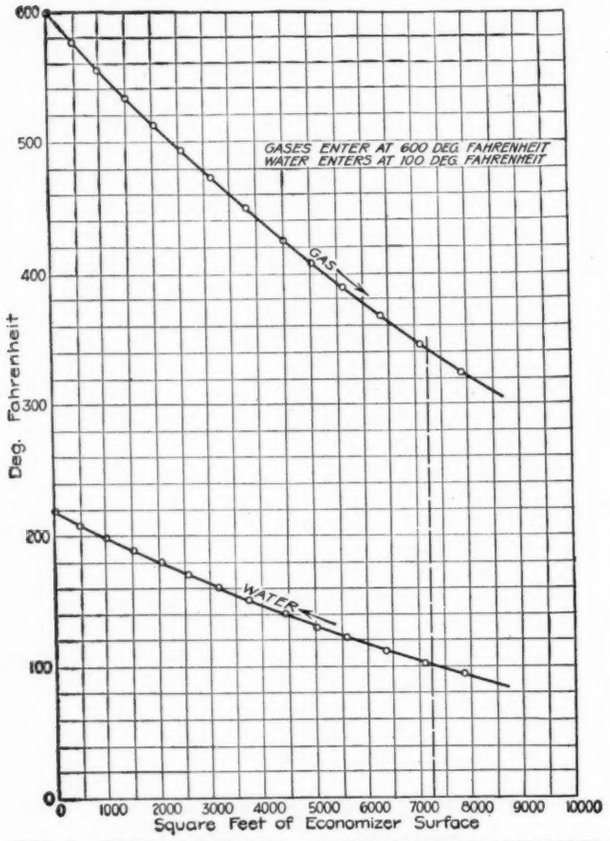


FIG. 3. CHARACTERISTICS OF ECONOMIZER ARRANGED FOR CONTRA-FLOW OF GASES AND WATER

that the heat transfer H per square foot per hour is $5.5 \times 484.3 = 2663$ B.t.u. Therefore, the surface required to raise 100,000 lb. of water through 10 deg. F. is $100{,}000 \times 10 \div 2663 = 376$ sq.ft. In tabular form this is represented by the first line of Table I. The next step is to take new figures for gas and water temperatures and tabulate as in the remainder of the

TABLE II. CONTRAFLOW, WATER ENTERING AT 100 DEG. F.

T_1	T_2	Tm	t_1	t_2	tm	Tm−tm	H	100,000 × 10	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	578.6	589.3	220	210	215	374.3	2,018	1,000,000	486	486
578.6	557.2	567.9	210	200	205	362.9	1,996	1,000,000	501	987
557.2	535.8	546.5	200	190	195	351.5	1,933	1,000,000	517	1,504
535.8	514.4	525.1	190	180	185	340.1	1,870	1,000,000	535	2,039
514.4	493.0	503.7	180	170	175	328.7	1,803	1,000,000	553	2,592
493.0	471.6	482.3	170	160	165	317.3	1,745	1,000,000	573	3,165
471.6	450.2	460.9	160	150	155	305.9	1,652	1,000,000	594	3,759
450.2	428.8	439.5	150	140	145	294.5	1,620	1,000,000	617	4,376
428.8	407.4	418.1	140	130	135	283.1	1,557	1,000,000	642	5,018
407.4	386.0	396.7	130	120	125	271.7	1,494	1,000,000	669	5,687
386.0	364.6	375.3	120	110	115	260.3	1,432	1,000,000	698	6,385
364.6	343.2	353.9	110	100	105	248.9	1,369	1,000,000	730	7,115
343.2	321.8	332.5	100	90	95	237.5	1,306	1,000,000	766	7,881

table. For convenience, the table is based on equal increases of 10 deg. in the feed-water temperature.

The data in Table I are plotted in Fig. 2. It is readily seen how the surface must be increased for a given rise of the water temperature as the temperatures of the water and gas approach each other. As pointed out previously, the efficiency of the boiler and the economizer is 80 per cent. The ashpit loss will be about 3 per cent. and the unaccounted for losses, radiation, etc., will account for about 3.5 per cent. Therefore the flue-gas loss will be 13.5 per cent., or 1350 B.t.u. per pound of coal.

Flue gases from a coal of the grade assumed will contain about 0.5 lb. of water in the form of superheated steam; therefore, as the total weight of gases is 12.25

TABLE III. PARALLEL FLOW, WATER ENTERING AT 150 DEG. F.

T_1	T_2	Tm	t_1	t_2	tm	Tm−tm	H	100,000 × 10	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	577.7	588.8	150	160	155	433.8	2,386	1,000,000	419	419
577.7	555.4	566.6	160	170	165	401.6	2,209	1,000,000	452	871
555.4	533.1	544.2	170	180	175	369.2	2,031	1,000,000	492	1,363
533.1	510.8	521.9	180	190	185	336.9	1,853	1,000,000	539	1,902
510.8	488.5	499.6	190	200	195	304.6	1,675	1,000,000	597	2,499
488.5	466.2	477.3	200	210	205	272.3	1,498	1,000,000	667	3,166
466.2	443.9	455.0	210	220	215	240.0	1,320	1,000,000	757	3,923
443.9	421.6	432.7	220	230	225	207.7	1,142	1,000,000	875	4,798
421.6	399.3	410.4	230	240	235	175.4	965	1,000,000	1,036	5,834
399.3	377.0	388.2	240	250	245	143.2	788	1,000,000	1,270	7,104
377.0	354.7	365.8	250	260	255	110.8	609	1,000,000	1,642	8,746
354.7	332.4	343.5	260	270	265	78.6	432	1,000,000	2,315	11,061

lb. per pound of coal, the gases will weigh 11.75 lb. and the water vapor 0.5 lb. The problem now is to find the temperature of the escaping gases. Assuming that the air entering the boiler is at a temperature of 70 deg. F., the temperature of the escaping gases may be found from the equation,

$$11.75 \times 0.24\ (t - 70) + 0.5 \times 0.48\ (t - 212) + 0.5 \times 970.4 + 0.5\ (212 - 70) = 1350$$

from which t=340 deg. F. Now referring to Fig. 2,

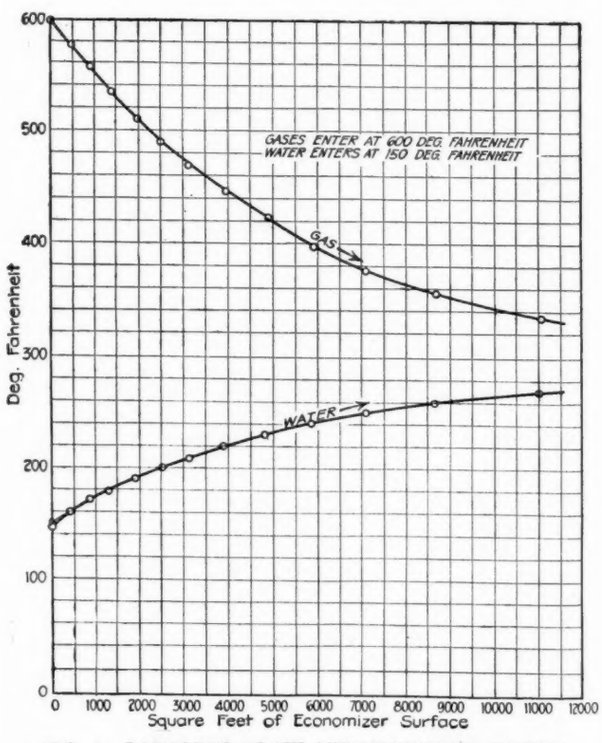


FIG. 4. PARALLEL-FLOW ARRANGEMENT, WATER ENTERING AT 150 DEG. F.

it will be found that for a final gas temperature of 340 deg. the surface required is 8000 sq.ft. Also, it will be observed that the feed-water temperature will be 220 deg. F., a rise in temperature of 120 deg. Fahrenheit from the assumed initial temperature. The return in heat units per pound of coal as fired is $6.3 \times 120 = 756$ B.t.u., or a return of 7.56 per cent. on a heating value of 10,000 B.t.u.

The contraflow method, in which the hottest gases meet the hottest water, will next be discussed. As before, the heat given up by the gases must equal the heat given to the water, assuming no radiation, etc. Therefore, the rise in temperature of the feed water for a given drop of gas temperature will be the same as in the case of parallel flow, but the difference will lie in the amount of surface required to bring about these conditions. The tabulation will therefore start with gases entering the economizer at 600 deg. F. and the temperature of the water leaving at 220 deg. F., as given in Table II.

Fig. 3 shows Table II in graphical form, and a study

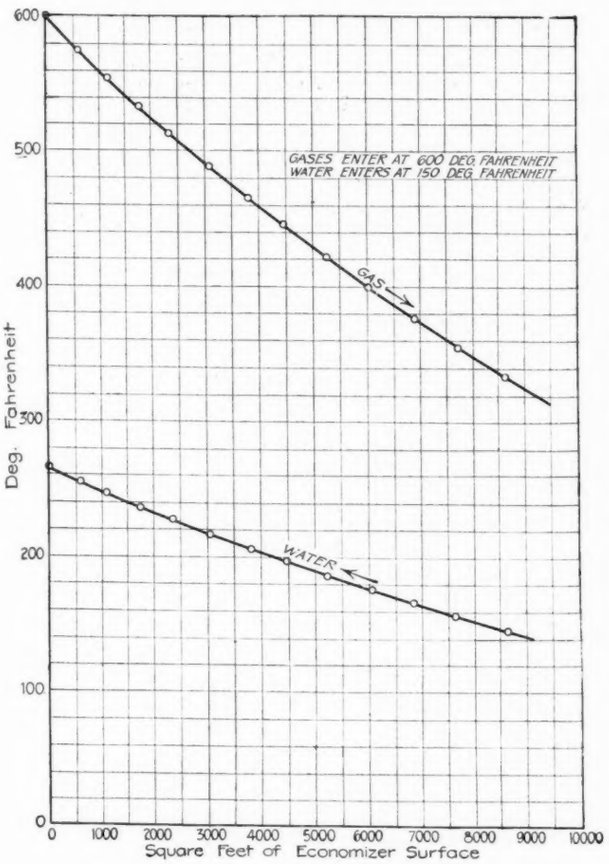


FIG. 5. CONTRA-FLOW ARRANGEMENT, WATER ENTERING AT 150 DEG. F.

of this diagram shows that to obtain a final gas temperature of 340 deg. F. it is necessary to install an economizer surface of 7300 sq.ft., which is just 700

TABLE IV. CONTRAFLOW, WATER ENTERING AT 150 DEG. F.

T_1	T_2	Tm	t_1	t_2	tm	Tm−tm	H	100,000 × 10	Surface Sq.Ft.	Total Surface Sq.Ft.
600.0	577.7	588.8	265	255	260	328.8	1,808	1,000,000	553	553
577.7	555.4	566.6	255	245	250	316.6	1,741	1,000,000	574	1,127
555.4	533.1	544.2	245	235	240	304.2	1,673	1,000,000	598	1,725
533.1	510.8	521.9	235	225	230	291.9	1,605	1,000,000	623	2,348
510.8	488.5	499.6	225	215	220	279.6	1,538	1,000,000	650	2,998
488.5	466.2	477.3	215	205	210	267.3	1,470	1,000,000	680	3,678
466.2	443.9	455.0	205	195	200	255.0	1,403	1,000,000	713	4,391
443.9	421.6	432.7	195	185	190	242.7	1,335	1,000,000	749	5,140
421.6	399.3	410.4	185	175	180	230.4	1,267	1,000,000	789	5,929
399.3	377.0	388.2	175	165	170	218.2	1,200	1,000,000	833	6,762
377.0	354.7	365.8	165	155	160	205.8	1,132	1,000,000	883	7,645
354.7	332.4	343.5	155	145	150	193.5	1,064	1,000,000	940	8,585

sq.ft. less than for an economizer connected for parallel flow. It is easily seen from the shape of the two diagrams, Figs. 2 and 3, that as the temperature of the gases and water approach each other, the surface required becomes very large for a given increase of water temperature in the case of the parallel flow as against contraflow. The advantage of the contraflow system becomes more apparent the larger the economizer.

The next question of interest is to determine just how much larger an economizer must be so that the same efficiency may be obtained with water entering at, say, 150 deg. F. as against the 100 deg. F. assumed in the previous calculations.

As the water is to enter at 150 deg. instead of 100 deg. F., the evaporation per pound of coal will be increased, but not the efficiency. Therefore, the fall of gas temperature for a given rise of water temperature must be refigured. The heat available is 8000 B.t.u., as before, but the heat given to 1 lb. of water is 1340 − 118 = 1222 B.t.u. Therefore, the evaporation is 8000 ÷ 1222=6.55 lb. per pound of coal. The ratio of the change of temperatures is $\frac{t_1}{t_w} = \frac{1 \times 6.55}{0.24 \times 12.25} = 2.23$.

With this information, the tabulation shown in Table III for the parallel-flow arrangement may be made.

Fig. 4 is the graph of Table III and shows that to reduce the temperature of the gas at the outlet from the economizer to 340 deg. F., as before, the surface must be increased to about 10,500 sq.ft., which is more than 30 per cent. greater than for the case shown in Fig. 2. If, however, the same size of economizer were used, the gas temperature at the outlet from the economizer would be raised to about 363 deg., with a corresponding loss due to the flue gases of about 1420 B.t.u., or 14.2 per cent. of the heat in the fuel, an increase of 0.7 per cent.

In Table IV will be found the tabulation corresponding to the case of the contraflow method of arrangement. In Fig. 5, the graph of Table IV, it is seen that the economizer surface required to bring the final temperature of the gas to 340 deg. F. is 8300 sq.ft. This is about 1000 sq.ft. more than is shown in Fig. 3, or an increase of nearly 14 per cent. If the surface is not increased, the gas-outlet temperature will be about 363 deg., as before, with an increased loss of 0.7 per cent. in the flue gases.

Any particular set of conditions can be assumed and the results can be easily worked out by the methods given, and the graphs will show reliable information as to just what to expect.

Buyer's Acceptance of Engine

A gasoline engine was sold under an agreement that it might be returned by the buyer if found to work unsatisfactorily after thirty days' trial. But he was induced to retain it beyond that time by the seller on representations that trouble which developed in operating the engine was due simply to the fact that it was new, the parts were tight, and that it would not operate well until used for some time. Under these circumstances it was decided by the Wisconsin Supreme Court in the recent case of Barta vs. Blahnik, 170 Pacific Reporter, 281, that it was not open to the seller to recover the agreed purchase price, as against the buyer's expressed desire to rescind the purchase because the engine was not as represented, on a theory that the buyer's retention of the equipment for more than thirty days' amounted to a final acceptance of it.

The Electrical Study Course—Current in the Inductances of a Three-Wire Generator

Discusses the manner in which the direct current of the neutral wire is superimposed upon the alternating current that normally flows through the balancing inductances.

THE direction of the currents in the inductances used with a three-wire generator depends on the relative values of the alternating and direct currents through them. In any event the current flowing is a combination of a direct and an alternating one, and its value will therefore be changing from instant to instant. Consequently, we shall have to investigate instantaneous values instead of continuous ones. To study the conditions that exist, let us refer to Figs. 1 to 4. In them C represents the commutator and S the slip rings of a two-pole three-wire generator, and L_1 and L_2 the inductances used in connection with it to furnish energy to a three-wire system over the mains A, N and B. Let us assume that the maximum exciting current taken by the inductances L_1 and L_2 is 5 amperes and that the inductances have 100 turns each. Then the maximum ampere-turns (amperes times turns) is $5 \times 200 = 1000$; that is 1000 ampere-turns are required to set up, through the core, a magnetic field that will generate a counter-voltage in the coils almost equal to the applied volts across the brushes (220 volts). It will be remembered that in the last lesson it was shown how there was only about one or two volts difference between the counter-voltage induced in the inductances and the voltage across the direct-current brushes, when the armature is in the position, Fig. 1, and that this difference between the applied volts and the counter-volts caused a current to flow that magnetized the core.

If 1000 ampere-turns are sufficient to set up a magnetic field in the core that will cause to be generated a back pressure in coils L_1 and L_2 almost equal to the applied volts, then if the ampere-turns are increased slightly the counter-pressure will become greater than the applied volts and the inductances L_1 and L_2 will

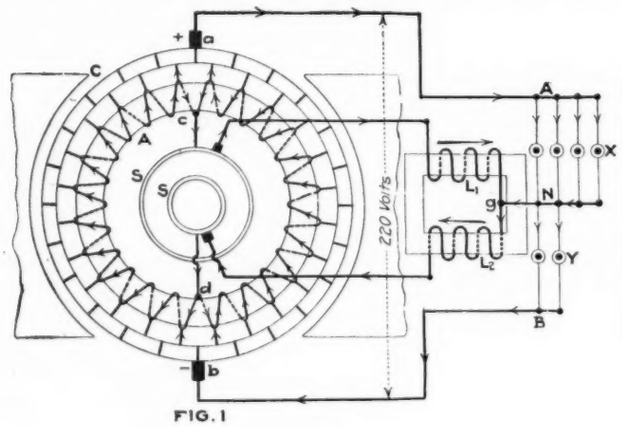


FIG. 1

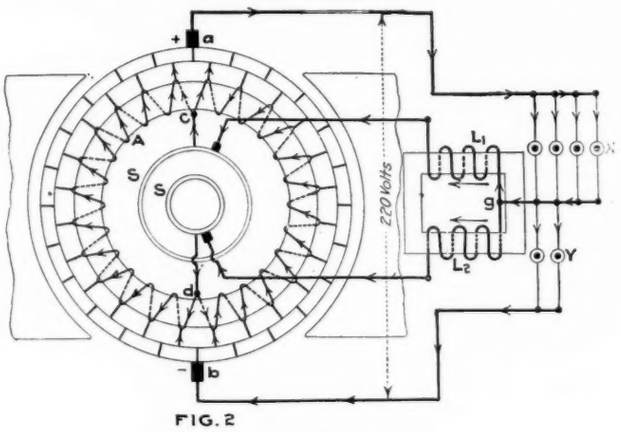


FIG. 2

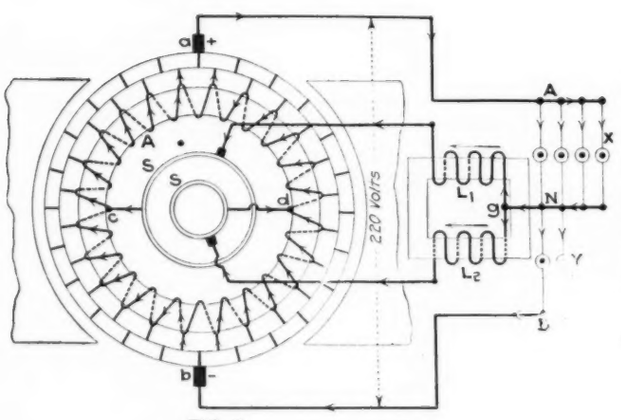


FIG. 3

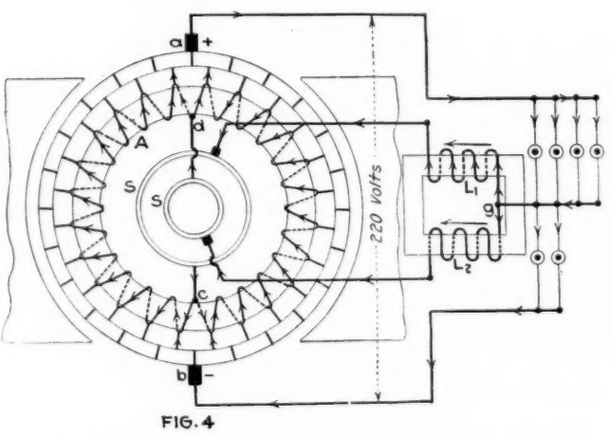


FIG. 4

FIGS. 1 TO 4. SCHEMATIC DIAGRAMS OF THREE-WIRE GENERATORS CONNECTED TO A LOAD

supply power to the system instead of taking power from the armature. This is just what happens in a three-wire generator, as will be shown in the following:

Assume in Fig. 1 that the load on the system is unbalanced so that 5 amperes is flowing in the neutral. For the position of the armature shown in the figure, up to the point where the unbalanced current is capable of supplying all the ampere turns, the current in the neutral will flow through L_2 to the negative point in the armature through the armature winding to the positive brush. Now if the 5 amperes flows through L_2 to the negative brush, it will be in the same direction as the

magnetizing current flowing from c to d, consequently will increase the ampere-turns by the value of the current in the neutral times the turns in L_2, or in this case $5 \times 100 = 500$. The total ampere-turns required are 1000; then, if 500 ampere-turns are supplied by the current in the neutral, flowing through L_2, only $1000 - 500 = 500$ will have to be supplied by the current flowing from c to d through L_1 and L_2. The magnetizing current will equal the ampere-turns divided by the turns in L_1 and L_2, or $500 \div 200 = 2.5$ amperes. That is, with 5 amperes flowing in the neutral and through L_2, only 2.5 amperes will flow from c to d. This will give 2.5 amperes in L_1 and $2.5 + 5 = 7.5$ amperes flowing in L_2. The ampere-turns supplied by L_1 equal $2.5 \times 100 = 250$ and those in $L_2 = 7.5 \times 100 = 750$ or a total of $250 + 750 = 1000$, which is correct.

If the current in the neutral was increased to 10 amperes and the total flowed through L_2, then this inductance would be supplying $10 \times 100 = 1000$ amperes-turns, or the total magnetizing current. Therefore no current will flow from c to d, but the counter-voltage across L_1 will now be approximately 110 volts since the magnetic field set up by L_2 also passes through L_1. The counter-voltage in L_2 is also approximately 110 volts, and this is just as it should be, since at the instant shown in Fig. 1, 220 volts exists between brush a and the negative point d in the armature winding, 110 of which is absorbed in causing the current to flow through the lamps between A and N, and the remaining 110 volts is used up in causing the neutral current to flow through L_2 against its ohmic resistance and counter-voltage. Increasing the load 10 amperes between A and N over that between N and B has caused slight unbalancing of the voltage, so that at the instant in question the voltage across A and B has decreased to a point where it is just equal to the counter-voltage in L_1; then an increase in ampere-turns in L_2, due to a further unbalancing of the load, will cause the back pressure in L_1 to be higher than the voltage between A and N, and L_1 will begin to act as a generator to supply power to the load between A and N.

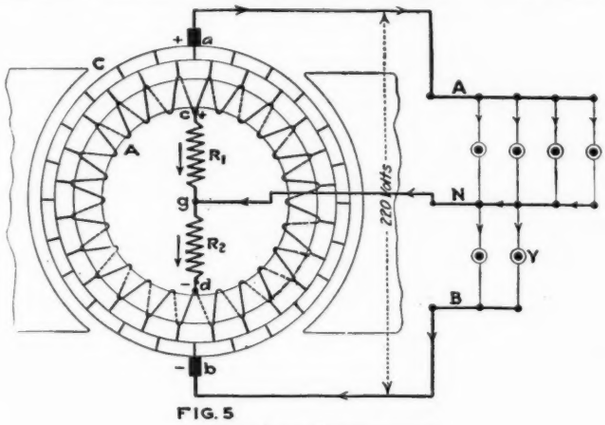


FIG. 5

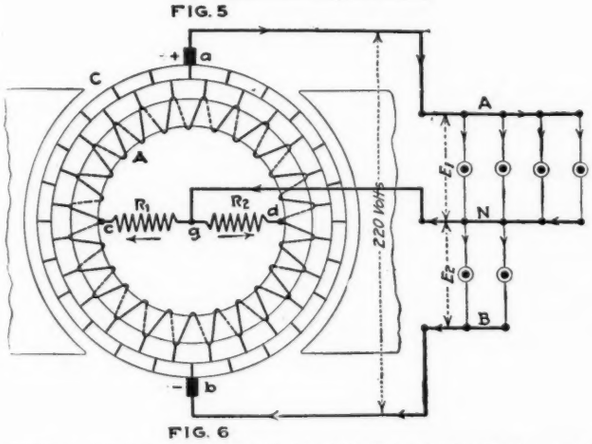


FIG. 6

FIGS. 5 AND 6. THREE-WIRE SYSTEM OBTAINED BY RESISTANCES CONNECTED TO TWO-WIRE GENERATOR

The foregoing is just the condition that we had with the balancer sets, when the load was unbalanced to the point where the machine running as a motor was supplying all the losses in the set, the voltage of the other machine was just equal to the voltage across the side of the system it was connected to; with any further unbalancing of the load one-half of the current was supplied from the machine operating as a generator and the other half from the main generator. Similarly, with the three-wire generator, Fig. 1, if the load is increased 10 amperes more, making a total of 20 amperes, 5 amperes of this increase will be supplied from the armature and will pass through L_2 from g to d and the other 5 amperes will be supplied by L_1 and will flow from g to c in an opposite direction to the 15 amperes flowing through L_2, as indicated in Fig. 2. Consequently, the $5 \times 100 = 500$ ampere-turns of L_1 is in opposition to the $15 \times 100 = 1500$ ampere-turns on L_2, which makes the effective ampere-turns equal to $1500 - 500 = 1000$, the same as when 5 amperes flowed from c to d through L_1 and L_2, or when 10 amperes flowed through L_2 only. Any further unbalancing of the load will continue to divide up equally between L_1 and L_2 and we will have a current flowing in one direction through L_1 and in the opposite direction through L_2.

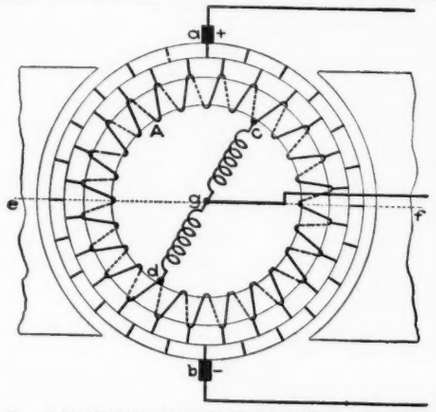


FIG. 7. DIAGRAM OF THREE-WIRE GENERATOR

Next let us investigate the condition that will exist when the armature has made one-quarter revolution, as in Fig. 3. In this position, as we found out in previous lessons, no voltage exists across c d. Consequently no magnetizing current will be flowing in L_1 and L_2, and no counter-voltage will be generated in the windings L_1 and L_2. However, 110 volts exists from brush a through L_1 to g, also 110 volts from a to g through L_2; therefore, the neutral current will divide up equally between the two inductances, 10 amperes flowing through L_1 and 10 through L_2 around through half of the armature winding to brush a. This is just as it should be, since the currents are flowing through the inductances in opposite directions and are equal; the ampere-turns of one are in opposition to those of the other and no flux is caused to flow through the core, consequently no counter-voltage will be induced in L_1 and L_2.

Consider next the condition when the armature has made one-half revolution, as indicated in Fig. 4. This is identical to what we have in Fig. 2 except that L_1 is now connected to the negative point in the armature and L_2 is connected to the positive point. Consequently, with the load unbalanced 20 amperes, 15 will flow through L_1 to c and 5 amperes through L_2 to d. Now, it will be seen that the current has increased in L_1 from 5 amperes in Fig. 2 to 15 amperes in Fig. 4, also in L_2 the current has decreased from 15 in Fig. 2 to 5 amperes in Fig. 4. It is this variation in the current that generates the counter-voltage in the inductances as the armature revolves and takes the place of the alternating current that flows in the winding when the load is balanced, or when the machine is running without load.

It must be remembered that although the discussion gives the impression of a considerable lapse of time from one position to another, the transition in reality is very rapid. For example, such an armature might be revolving at a speed of 1500 r.p.m., which is equivalent to 25 revolutions per second, and it would therefore make one revolution in 1/25 of a second. Since all the changes in current described in the foregoing take place in one-half revolution, they occur in the space of one-fiftieth of a second.

We now see that through the use of inductances we are able to cause the current in the inductance between g and the positive terminal a to flow from g to a, which is impossible to do when resistances are used. Thus, in Fig. 5, which represents resistances instead of inductances, the current through R_1 would always have to be in the same direction as through R_2 for the position shown in the figure, the only difference being that the current through one would be greater than that through the other. Thus, in the position shown in Fig. 5 the current through R_2 would be greater than that through R_1. Of course, for the position shown in Fig. 6 the neutral current divides equally between R_1 and R_2 and flows in opposite directions as indicated. In the inductances Figs. 1 to 4, however, the current in L_1 is in the opposite direction from that in L_2 in all cases except those when the current in the neutral is very small. Such an arrangement of inductances therefore provides a convenient means of accomplishing the same results as are obtained with a balancer set, with an even greater degree of economy, and with the further advantage of dispensing with moving machinery.

In the explanation of the action of the inductance and how the current divides between them, many other elements that occur to affect the actual conditions have not been considered. This, however, has been done to simplify the reasoning as much as possible.

The problem of the preceding lesson concerned the voltages in a three-wire generator, such as that represented in Fig. 7. The voltage across a b was given as being 220 volts, and that across c d 190 volts. It was required to find the voltages across a c and d b and to determine whether the following points were positive or negative to each other, namely: c to d, c to a, d to b. It was also required to find the voltage across a g and g b, whether g is positive or negative with reference to a and b, and whether the position of the armature has any effect upon these latter voltage relations. The sum of the voltages across a c and d b must be equal to the difference between the voltage across c d and the 220 volts across brushes a b, and must therefore be $220 - 190 = 30$. Half of this exists across each of the sections a c and d b, so that the voltage across each is $\frac{1}{2} \times 30 = 15$ volts. The potentials of all parts of the armature winding above the center line e f are positive with regard to the potentials of all points below it. Consequently c is at a higher potential than d when in the position shown. As c approaches a its potential becomes greater until at a the two coincide; which means that in the position it occupies in the figure, c is at a lower potential than a. In a similar manner d must be at a higher potential than b since its potential gradually decreases as it approaches b. Since there is a constant voltage of 220 volts across a b, and since it has been established that the potential of g is always midway between that of a and b, it follows that $\frac{1}{2} \times 220$, or 110 volts, must exist across a g and g b. Since g is between a b it must be negative with reference to the former and positive with reference to the latter. Since the voltage across a b is constant and g is always the mid-point, the position of the armature has no effect on the voltage relations between the points a, g and b.

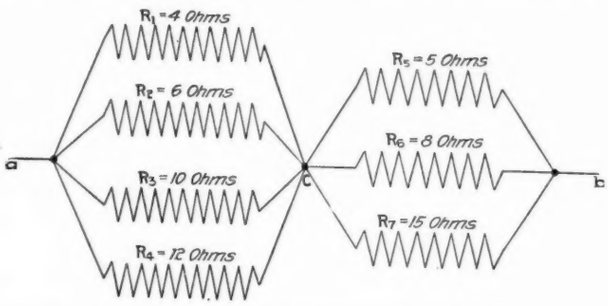
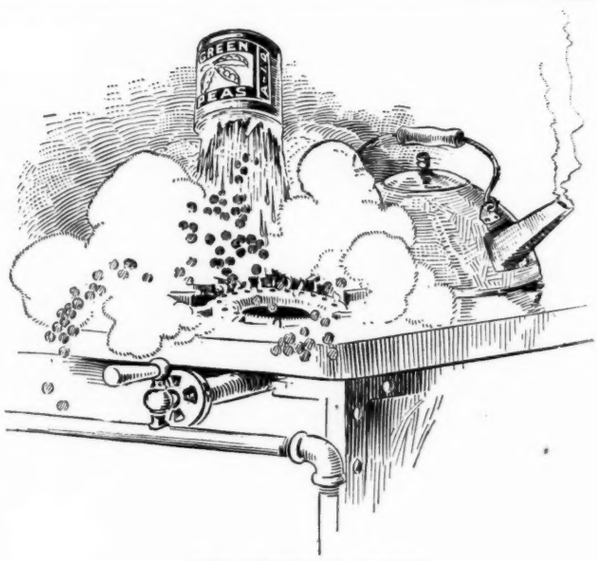


FIG. 8. RESISTANCES GROUPED PARALLEL-SERIES

Seven resistances, R_1, R_2, R_3, etc., are connected as indicated in Fig. 8. A voltage of 240 volts is applied across the points a b. What will be the value of the current flowing in each of the resistances?

There are various types of boilers and most of them will evaporate the same amount of water per pound of coal, if they are designed with the proper proportion of heating surfaces and grate area.



THE BURSTING POINT

EDITORIALS

Large Power Monopoly Economically Difficult

CHAIRMAN Alonzo R. Weed of the Massachusetts Gas and Electric Light Commission uttered a most significant truth at a recent hearing before the legislative committee on waterways and terminals at Boston, when he stated that power cannot be sold in large blocks except on a competitive basis. For this reason the man with a demand of, say, one hundred horsepower or more finds himself in most cases in a strong position to deal with an electric service company, when he comes to discuss power-contract terms. The fear is sometimes expressed that large power organizations can so completely dominate their territories that no one can withstand any attempts which may be made to "charge all the traffic will bear," as the saying goes. As regards the larger users, there is in most instances really little to fear in this respect. Rates to large users cannot attract the desired business unless they come fairly close to or below the cost of local production, including in that cost all the proper fixed charges and valuations. Even the small consumer is often in a position to bargain successfully, or if not, the possibilities in the way of isolated-plant service may reduce the regular rates for such supply sufficiently to warrant considering buying a part at least of the energy required. It is often forgotten that those who sell electricity really face competition in quite a number of forms and the lesson of this is that every operating engineer should undertake economic analyses of his plant's service and working without the least hesitation, requiring every outside offer of energy supply to clearly demonstrate its economic superiority to existing or possible results under skillful operating control.

Liberty has a message for all of us when she tells us that we must keep faith with those who sleep in Flanders Fields.

HOW CAN WE KEEP THE FAITH?

By over-subscribing the Victory Loan.

By doing justice to every worker and by meeting with patience and in a spirit of compromise the troublesome industrial problems ahead.

By rendering a fair day's work for a fair day's pay.

By insisting that the way of sound progress is by evolution, not revolution.

By making, each in his particular job, whatever sacrifices are necessary to bring about that reign of justice for which our sons and brothers suffered and laid down their lives.

They died that we might live in peace and happiness; shall we cast away their blood and scoff their death by strife and disorder and injustice?

Uniform Boiler Rules

A BOILER knows nothing about politics or geography. A given boiler operated with the same degree of care and intelligence is just as safe in Massachusetts as in Texas, and no safer.

On page 611 some of the principal differences between the Code of the Massachusetts Board of Boiler Rules and that of the American Society of Mechanical Engineers are set forth, as they apply to new boilers and new installations.

There may be some justification for differences in requirements as to existing installations. A state that has exercised supervision for a number of years may have gotten its boilers by gradual rejection and improvement into such a condition as to admit of the application of rules, which, if abruptly imposed in a state that has had no restrictions, would condemn thousands of boilers still reasonably safe. In this case the danger of the risk from explosion must be balanced against the loss by confiscation, the positively dangerous removed, and the process of gradual improvement instituted by insisting upon approved design and materials for new work with a gradual retirement of less reliable types.

But for new work the question is, or ought to be, one of simple engineering. If a longitudinal butt joint over twelve feet in length is dangerous in Massachusetts, it is just as dangerous in Ohio. If it is a source of real weakness, the A. S. M. E. code is at fault in not prohibiting its use. If it is not, the Massachusetts Board is unreasonable to exclude it. If the use of the fusible plug is so essential as to be required by law in Massachusetts, it ought to be required by the A. S. M. E. Code. All the differences to which the article in question calls attention are susceptible of conciliation by unbiased engineers when in possession of all the attainable information on the subject. The desirability of uniformity in regulations of this sort is too obvious to require argument. It is particularly desirable to the boiler manufacturer, who must otherwise keep the complicated assortment of stock and fittings necessary to meet a variety of requirements, run the risk of having his boiler rejected through the oversight of some idiosyncrasy of the law of the locality into which it is going—for cities as well as states have rules—and who cannot build boilers for stock, because each must be built to the code of the state or city where it is going. It is also desirable for the boiler inspector who could become thoroughly versed in one set of rules and keep up with its revisions, but who sees himself hopelessly swamped with a different set of rules for each state and a lot of others for different cities. And, too, it is desirable for the purchaser and user of boilers, for a uniform code would make standardization possible with all that it means in efficient and less expensive production, and a product that can be of only one kind.

Get together, gentlemen, and reconcile your differences! If they are of much of any moment, the su-

periority of one or the other treatment ought to be demonstrable. Those which are not of sufficient moment to be so determined could well be obliterated by mutual concessions. If the superiority of either is not sufficient to be demonstrable to a board or committee of unprejudiced experts, adopt either the one or the other and let us have a standard code and uniform practice.

The Clinker Grinder

WITH the continuing wider use of the large boiler and the stoker capable of high rates of combustion, mechanical means for the removal of ash from the boiler furnace became necessary to expedite operation. This is the prime function of the clinker grinder. As the road of refinements is the direction one must now take to better power-plant over-all efficiency, designers of modern clinker grinders strive to reduce to the lowest practicable minimum the combustible in the ash discharged from the furnace.

Elsewhere in this issue is an article treating of the development, present status and trend in the design and operation of these new appendages of the mechanical stoker. The author gives emphasis to his statement that the clinker grinder is intended for the exceptional rather than for the usual power plant. That is, for the plant burning large quantities of coal and operated by highly competent labor, the grinder is successful, but plants of usual capacity with the changing labor to which they are subjected are better off with the dump plate, which is now a part of the stoker, than with the clinker grinder of modern design.

Keeping Faith with the Fallen

HISTORY contains no finer example of altruism than that displayed by America as a nation during the recent war. With no aspirations for power, no secret yearnings for territory and no ancient grudges to settle, but with a firm and unalterable belief in those principles of freedom by which she herself had achieved greatness, she spent lavishly of her abundant wealth and freely of her blood that the world might enjoy with her the blessings of liberty.

So far as the United States is concerned, the war was fought and won by a united people. But for the unanimity of thought, purpose and action of a hundred million Americans there would have been no such splendid ending. Our soldiers battled so sturdily and successfully because they knew they were backed by the wealth and the will of the nation.

Those who fell—may we never grow indifferent to the magnitude of the debt we owe them!—yielded up for an ideal the one thing that was dearest to them. Faith in the righteousness of that ideal and in the resolve of the nation to bring it to realization sustained them.

Shall not that faith be kept? Shall it be said that we who remain and on whom they relied are recreant to that trust? Shall Liberty—depicted so graphically in the colored insert that accompanies this issue—call in vain to us to keep our promises to the heroes who lie beneath those rows of mute crosses?

The appeal comes in a score of ways. We can keep faith with them by supporting the institutions and principles for which they died—by scotching the snake of Bolshevism, by laboring to maintain industrial tranquillity, by meeting taxes cheerfully and philosophically, by Americanizing the immigrant and the ignorant, by fostering patriotism, by doing our own humble tasks as efficiently and capably as they did theirs.

We can keep faith with the dead by completing the work that their sacrifice made certain of success. But time and thought and money must still be spent to accomplish that end.

Subscriptions to the Victory Liberty Loan will show how well we keep our pledged word.

Some men seem to think that as soon as they obtain a position in a boiler room they are anchored there for life as firemen. Be this as it may, there is this to remember: The man who knows more about the fuel he burns and how and why it burns and puts his knowledge into practice, is the man who will be elevated to the higher and better paying boiler-room positions.

It may be difficult to draw the line between bituminous and sub-bituminous coals on the basis of moisture content, but the point may be settled by the behavior of the two fuels in weathering. Sub-bituminous varieties shrink, crack irregularly and partly disintegrate on exposure, while bituminous varieties shrink very little and do not disintegrate while drying.

Engineers hold various opinions regarding the construction of boiler settings. Some are in favor of designing them with an air space and others favor the solid wall construction. There is much to be said in favor of both types of settings, and it is probable that our readers may have interesting data on the subject.

The average man looks with favor on the job that is permanent. For that reason there should be a ready response to the appeal of the United States Shipping Board for first assistant engineers to serve on our merchant ships.

Universal raising of wages cannot permanently improve the condition of the workers if it is accompanied by smaller output and shorter hours. There must be greater efficiency and increased production.

When we see some fellow take the floor every fifteen minutes at an engineers' meeting, we are reminded that a babbling stream has to spread itself considerably to make up for its lack of depth.

After the Prohibition Amendment goes into effect, coroners' juries will have to account for disastrous boiler explosions on some other ground than that of intoxicated firemen.

Americanization is a filter that will rid us of such undesirable trash as hyphenated nationalities, Bolshevist tendencies and fanatical devotion to foreign interests.

From reports that come to us from time to time, it is evident that the safest place in the world is not to stand in front of a cylinder head.

The American army will need 50,000,000 gallons of fuel oil during 1919. Sure! we have oil to burn.

Correspondence

Difficulty Experienced in Getting a Generator up to Full Voltage

The armature of a 240-volt compound-wound direct-current generator was removed for rewinding, and upon being replaced the machine failed to generate. On the assumption that the residual magnetism had been lost, the shunt-field was flashed, in the usual way, from the bus with current from a 220-volt battery. This gave no result, the voltmeter remaining at zero when the machine was again started.

The shunt-field terminals were next connected with another machine generating about 210 volts. This brought the voltage up to about one-half normal value, but no further. Upon replacing the shunt-field connections the voltage again dropped to zero. Reversing the armature leads was next suggested, and this being done, the machine immediately picked up but in the wrong direction. The machine was stopped and the field again flashed from the battery and this ended the trouble.

Now I wonder if any of *Power's* readers will care to give the explanation for the benefit of those of us who are young in the profession—especially the reason why the machine generated the 120 volts when separately excited.

ROBERT TOMLINSON.

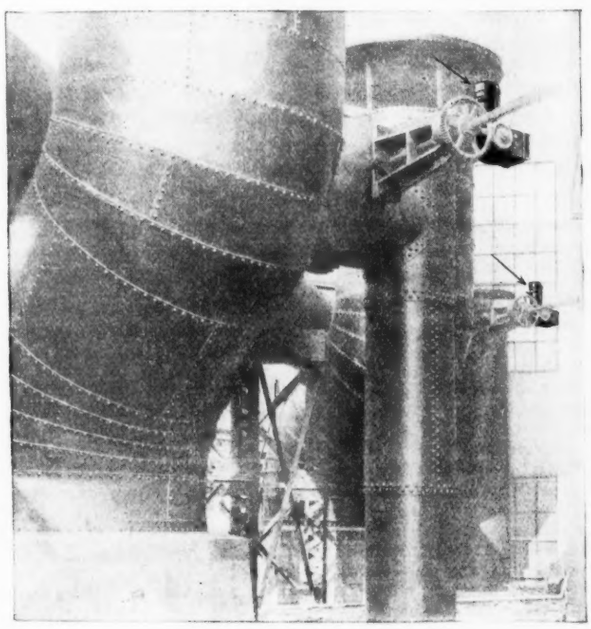
Wheeling, W. Va.

Turbo-Blower Valve Control

After reading the article, "Placing Valves in Unsafe Positions," by V. R. Hughes, in the Feb. 25 issue of *Power*, it occurred to me that perhaps engineers would be interested in a description of two valves installed at the plant of the Mark Manufacturing Co., Indiana Harbor, Ind. These valves are on the delivery side of turbo-blowers that supply 34,000 to 55,000 cu.ft. of air per minute, at 14 lb. pressure, to the blast furnace. The air is taken in through two 72-inch intakes, the screened top of one of them being visible in the illustration. The 36-in. discharge lines lead from the blowers in the power house to the main discharge line outside. Here two 36-in. gate valves are located at the point where the 36-in. lines enter the 48-in. main discharge line.

From the illustration it will be seen that the valves are placed approximately 15 ft. above the ground, hence they would be very inaccessible to operate by hand. Besides, it would be inconvenient to operate the steam throttle on the turbo-blowers and valves simultaneously. At least two attendants would be required to close the throttle of one turbine and a gate valve at anywhere near the same time. To make the operation of the valves convenient and to guard against any serious irregularities of the air flow to the blast furnace, two Dean valve controls were installed in the two 36-in. discharge lines with the valve-control stations near the turbine throttles. With this equipment the engineer can start the turbine and then, by merely placing the handle of the valve-control station in the open position, open the corresponding discharge valve. This convenient and speedy control is especially desirable when changing from one turbine to another. The importance of being able to open and close these two valves rapidly will be appreciated when one remembers that blast furnaces are seldom shut down, but it is often necessary or desirable to shut down a turbo-blower.

The control is electrical in operation, using a fully inclosed motor connected to a system of combined worm and planetary gearing for the purpose of speed reduction to the valve stem. The gearing is inclosed in an oil-tight casing, and the limit mechanism is included in a space above the gearing. All cables from the motor to the limit switch are incased in steel conduit,



A 36-IN. GATE VALVE 15 FT. ABOVE THE FLOOR OPERATED FROM A CENTRAL STATION

and the unit is as impervious to moisture as it is possible to make it.

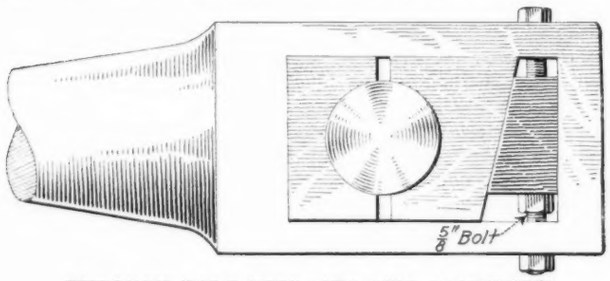
The valve gate is driven directly into the seat, under power, and to the exact point of tight closing, after which the trip mechanism releases the motor and gears from the valve stem, thus preventing overtravel due to momentum of moving parts. In this way there is obviated any inability to securely seat the gates because of the motor circuit being interrupted before the limit of travel is reached and the gate being allowed to drift into its seat.

Control of the valves is secured by small control stations placed in cast-iron boxes suitable for attaching to wall or floor standards, and as many points of control as are desired, for one valve, may be obtained, at any varying distance from the valve. Each station is fitted with indicating lights showing the position of the gate.

Milwaukee, Wis. F. M. NOURSE.

Uses a Single Wedge Bolt

I have had trouble with wedge bolt breaking off below the wedge. As a remedy I removed the ¾-in. bolt and put in a ⅝-in. bolt with a nut under the wedge, as shown in the illustration. This overcame my trouble



THROUGH BOLT REPLACES TWO CAPSCREWS

and the bolt makes a better and safer job than the commonly used capscrew, and it does not loosen up as does the ordinary type of bolt. M. J. MERRELL.

St. Louis, Mo.

Sources of Fuel Losses

Following is a copy of a letter I wrote some time ago to the engineers in charge of power plants under my supervision, pointing out wherein some of the losses are likely to occur:

It is demanded by the United States Fuel Administration and it is highly desirable that we spare no effort to cut down the consumption of fuel in our plants.

I would like to call your attention to some of the most common and most easily preventable sources of waste of fuel in stationary power plants. Probably the greatest loss of heat is up the smoke-stack. In the best-designed and most economically operated plants this loss will be about 15 per cent. of the total heat in the fuel and may be called unpreventable. In a poorly designed and carelessly operated plant it may easily be, and often is, 50 per cent.; that is, one-half of the heat in the fuel gone up the stack, from which we have derived absolutely nothing. What are the causes of this enormous loss and what can we do to prevent it?

Are you aware that a coating of soot ⅛ in. thick on the heating surface of your boilers will cut down the heat-transmitting efficiency 10 per cent. and as the thickness of soot increases, the loss increases a great deal faster?

In coal-burning plants the engineers should see that the boiler tubes are blown out thoroughly with dry, high-pressure steam or air at least two or three times each 24 hours. In oil-burning plants once a day will be sufficient if the fires are properly handled. You will find that it is quite an art to get just the right adjustment of steam and oil and air to the burners to obtain the best results. Return-tubular boilers should have a good scraper run through the tubes once a week.

Another common cause of heat loss is scale in the boilers; a coat of scale ⅛ in. thick will cause 10 per cent. of the heat in the fuel to go up the stack because it cannot get through the scale and into the water. And remember this: The only heat that makes steam is the heat that gets through the heating surface of the boilers and into the water.

So with a coat of soot ⅛ in. thick on one side and a coat of scale ⅛ in. thick on the other, 20 per cent. of the fuel value which should have gone into the water to make steam is going to waste up the stack. So be sure that your boilers are kept clean inside and out.

But the worst is yet to come. I believe that the cause of the greatest loss of heat up the stack is excess air. For complete combustion every pound of fuel requires just so much air. If we could admit just the right amount of air to the furnace there would be no loss from this source. This is impossible in practice, but by careful handling of the fires and intelligent manipulation of the dampers we can reduce the loss to a minimum.

Careless firing and poor adjustment of oil fires can easily result in a loss of 25 or 30 per cent. from this source. Add that to the 20 per cent. loss from soot and scale and you have a deplorable, though all too common, condition. Every pound of air over and above that required for complete combustion goes through without doing any good whatever; but when it comes out at the top of the stack it is mighty hot, and it took good coal or oil that cost good money to make it hot—all lost.

If there are any crevices in your boiler walls, excess air is going in there and taking good heat units up the stack. If your damper is wide open and your fire is too thin or has holes in it, large quantities of excess air are going through, robbing your boilers of the heat they should have. With oil fires, if you have your damper wide open with a light fire, great quantities of excess air will be going through your boilers.

It is up to us to get onto our jobs and watch these things closely and reduce the losses to a minimum and show that we are real engineers, not just starters and stoppers of engines and pumps, etc. I would like to see every engineer on the division take at least one good technical journal devoted exclusively to power-plant engineering. If closely studied, you will get the worth of the subscription price, and often a great deal more, from every issue.

May I ask the engineers in charge of plants to particularly interest themselves in the matters referred to in this letter to the end that we may have the most economically operated plants on the Santa Fé? If we do our part and show that we are worth it, it will be much easier to gain recognition of the fact that we are men in responsible positions in whose hands rests the saving or wasting of thousands of dollars—men in positions requiring skill and intelligence second to none.

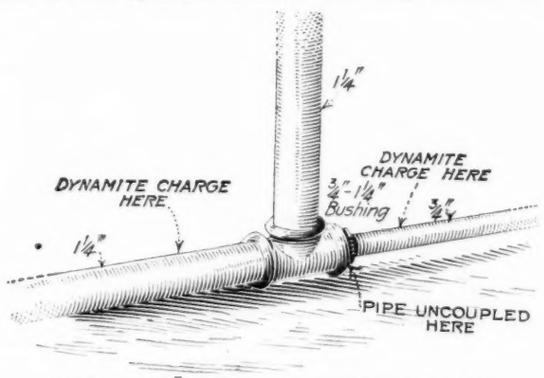
Another matter: See that the water from the feed-water heaters goes to the boilers as hot as the pumps will handle it—the hotter we put it in the boilers the less fuel it will take to make steam of it. W. G. CAMP.

Winslow, Ariz.

Dynamite Uncoupled Pipe Line

Last winter I had a peculiar experience that I would like to have explained. I was having some water main laid, and as the ground was frozen, dynamite was used to loosen up the ground in order to get the work along faster. One stick of dynamite was used in each hole. The holes were about four feet apart, and the dynamite did the work fine. This work was done for a state institution where there are some old water pipes in the ground.

My peculiar experience was as follows: Two charges of dynamite were placed, as shown directly over a water



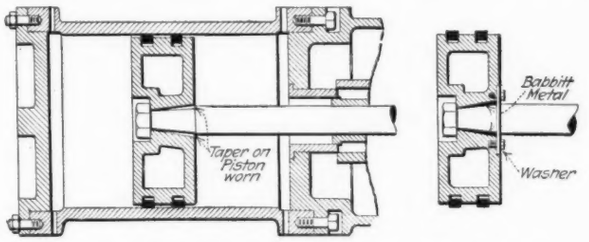
PIPING AND POINT OF PULLING APART

line having a tee from which there is a service branch. This tee is 1¼ x 1¼ x 1¼ in., reduced with a bushing to ¾ in., and the exploding of two sticks of dynamite uncoupled the water pipe at the tee, although neither the threads on the ¾-in. bushing nor the threads on the ¾-in. nipple were damaged. Repairs were made with the same bushing and nipple, and the joint was made up tight under a water pressure of 30 pounds.

Chester, Ill. E. S. KIMMEL

Loose Air-Pump Plunger Made Fast

Our air pump began pounding badly and the vacuum dropped back at intervals. Upon taking out the plunger, I found the piston loose on the rod, as shown in the illustration. It was made fast in the following way and it has given no trouble since. I made a washer out of ½-in. copper to fit the piston rod and fastened it to the



PISTON AND ROD BEFORE AND AFTER REPAIRS

piston with two ½-in. capscrews. I replaced the piston and rod in the pump, put in the piston packing to hold the piston central and bolted the follower plate down. Babbitt metal was then poured into the recess and peened down, and after fastening the washer securely, the job was done. JOHN T. LOCKETT.

Trenton, N. J.

Furnace Heat-Resisting Material

The present-day operating engineer should receive the sympathy of everyone for having to listen to the line of talk advanced by salesmen who are presenting boiler-wall cements, high-temperature cements, firebrick that will not melt, heat-resisting paint, etc. It is remarkable how a salesman will talk about the heat-resisting qualities of his furnace cement or of the high temperature that his firebrick will withstand. He knows of the difficulty the engineer has in getting a reliable line on the performance of any refractory material used in the furnaces of the larger power plants, as the boiler load on the individual unit of a large plant is at best a variable quantity.

I have seen the very best of the so-called heat-resisting materials show signs of deterioration after a prolonged banking period, this trouble being evidently due to checks or cracks having developed during periods of comparatively low temperature. Some might think that in furnace practice we should take into consideration only the maximum temperature conditions, whereas the lower temperature conditions may prove to be more damaging.

The question then arises as to the best method of checking the performances of the furnace linings on trial. Some suggest a record of the steaming and banked hours, others the maximum rate of steaming as indicated by the record of a steam-flow meter; others take into consideration the apparent horsepower-hours developed; but with all these, one period of injudicious banking with the doors open with full or partial draft may do more damage than several days of maximum service.

I have found that a good way to get a line on the qualities of the various furnace cements, brick, etc., is not to build a complete furnace with any one product on trial, but to divide the surface, say using one make on one side wall and another make on the other; the bridge-wall can be divided also. If this is done, the work should be under the supervision of a representative of the manufacturers, and instead of being placed upon trial the material should be paid for so that if a failure occurs, as it generally does, the engineer will not be bothered by requests for a repeat trial. Work installed in this way is subjected to like changes in furnace conditions, and after the test there is no doubt as to which is the best material. JOHN F. HURST.

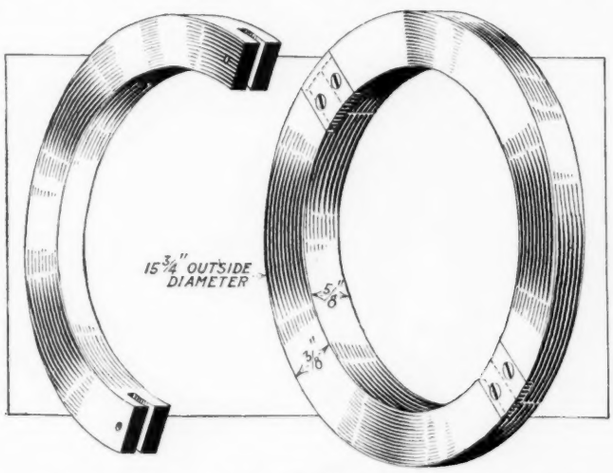
Louisville, Ky.

Repairing Oil Rings of Gas Engine

On examining the outboard bearing of a 650-hp. vertical gas engine that had been giving considerable trouble, it was found that the oil ring was broken in two places, leaving it practically in halves. To make a new ring and raise the shaft to get the bearing out to put the new ring in place would take approximately four days.

The ring was 15¾ in. outside diameter, ⅜ in. thick and ⅝ in. wide. The broken pieces were removed and a piece cut out of one side of the ring at the break to a depth of $\frac{5}{16}$ in. and about ½ in. long on each side of the break. Next a ¼-in. hole was drilled and tapped, one hole on each side of the break. Pieces were then fitted in the offsets cut in the ring and drilled for ¼-in. screws and in line with the tapped holes in the ring. The lobs of the plates were countersunk on one side to allow the screw heads to come flush with the metal. The plates were next secured to the ring by screws. All were filed to the same radius as the ring, both inside and outside. The ring was then put in place and has been running and doing good work for the last three years. It is shown at the right of the illustration.

Another good way to repair broken oil rings of small size is shown at the left of the illustration. For rings



TWO METHODS OF REPAIRING THE OILING RINGS OF A GAS ENGINE

that have not enough stock to cut out and set in a piece, as in the first instance, a good way is to split the ring in the center of the width, as shown. This is done on each broken end. The corresponding ends are then put together and pieces of tin inserted in the slots and held in place by drilling through the side of the ring and the tin keepers, using a small piece of copper as a rivet to hold the tin and ring in place. If tin is not at hand, a piece of a saw blade can be used after drawing the temper. R. G. CURREN, JR.

Kittanning, Penn.

Difference in Water Level in Boilers

I read with interest an article by F. R. McLean in the Feb. 11 issue of *Power*, page 201, relating to "Differences in Water Levels in Boilers." My experiences with steam boilers, especially in connection with water levels, may be of some value, and are as follows:

Upon installing feed-water regulators on three-drum horizontal-water-tube boilers, I have noticed effects similar to those described by Mr. McLean. However, I have also noticed this in boilers set singly, as well as in batteries. I have observed this effect on hand-fired as well as stoker-fired boilers, so it can hardly be caused altogether by the condition of the fire. It is sometimes difficult to observe this result on hand-fired boilers, because firing has its effect on the water level also.

I believe this difference in water level is due to the feed or method of feeding as much as to the fire. I have found that low water frequently occurs in the drum nearest to the main feed and the highest water in the drum farthest from the main feed. With some boilers it is customary to run the feed line over the top of the drum heads, dropping down to each drum. When the feed is throttled so that the flow through the pipe is gradual, it is probable that most of the water drops down the first pipe it comes to, hence introducing comparatively cold water into the drum nearest to the main feed. This will cause a circulation through the boiler toward the farthest drum and because the coldest water is in the near drum, most of the steam will be formed in the farthest drum or in tubes under it. This theory is borne out by Mr. McLean.

He also says: "When the individual feed line to one drum was found obstructed, that section would show high concentration of salts, mud and scale. By installation of orifices of slightly different sizes in the individual feed lines, a reasonably uniform concentration of deposits was obtained in all three drums."

Usually, in a double setting the feed comes from both sides, so this would cause the highest level in the center of the setting. I believe a better distribution of water would be obtained by running the main supply pipe under the drums and coming up to them. This probably would interfere with the doors unless the connections were made short or curved. Perhaps it would be better if the boiler manufacturers or erecting engineers would increase the size of the feed line progressively across the front of the boiler, instead of decreasing it to eliminate as much friction as possible. It is doubtful, though, if this alone would prevent most of the water going down the first pipe at low loads. There are so many factors involved that a single orifice under constant pressure can hardly be expected to take care of all conditions.

I have also noticed the difference in pressure between drums even when apparently plentifully supplied with equalizers. I believe it is possible to have the same level shown by a column in one end of a drain as the other, provided the baffles inside the drum are placed so as to insure this. However, there is no doubt that with steam rising in the front header and not in the back header, the specific gravity in the front of the boiler is less than in the back. Hence, there must be a difference in level. This was shown by Paul Bancel's interesting experiments on a small boiler, as described in the Transactions of the A. S. M. E. It has also been borne out by innumerable other experimenters and observers.

Erie, Penn. V. V. VEENSCHOTEN.

Overheating Hot Water Wasteful

It would seem at first glance that the statement in the letter by W. T. Meinzer, on page 256 of the Feb. 18 issue, on "Overheating Hot Water Wasteful" is true, but conditions often change things.

For instance, when it comes to dollars and cents, it does not make much difference whether you use 1000 lb. of water at 180 deg. F. or whether you use 1800 lb. at 100 deg. F. I had an experience along this line several years ago in a large modern factory building designed to house 1000 employees. Every floor was equipped with modern lavatories, and the help were supposed to come to work and go home clean. The tank for heating the water was suspended high enough above the boilers to return the condensate from the coils in the tank to the boilers by gravity.

The temperature was regulated automatically by a thermostatic control, and everything apparently was according to the best-known methods. By the way, the exhaust steam was all used in the process, so it was useless to think of exhaust for the hot-water service. More or less hot water was used during the day, but the genuine pulls came at 11:45 a.m. and 4:45 p.m. Different ones were detailed to fill the sinks with water for each floor, and they turned the hot-water faucets wide open in about twenty or thirty lavatories numbering from six to ten sinks each.

Now they wanted the water about 100 deg. F., and so it had been carried at 110 on the tank, but they did not get it half fast enough. The plant was designed to carry the hot water at 180 deg. F. originally, but to try and save a little fuel the engineer had cut the temperature. As the returns from the coil in the tank were well covered and came back properly, the saving was very little but the trouble it caused was considerable.

If a system is designed to furnish a certain amount of hot water per hour at a higher temperature, it will do it on smaller pipe than a lot of water at a lower temperature. This was the trouble in the case cited. It was figured that the hot and the cold water faucets would be opened together, so that but half the hot water would be used, thus supplying all faucets at practically the same time.

I put the temperature back where it was intended to be, and a few more degrees for good measure. As near as we could weigh the coal, we could not detect any difference in the amount burned, but the superintendent, the manager and even the president of the company visited the power plant and said the service was the best it had been for two years.

We also lowered the ball floats in the toilets about one inch and saved an amount of water almost unbelievable. I do not want to go on record as saying that coal cannot be saved by lowering the temperature—it sounds very good—but I am citing this case as an example.

Some years after this experience I was asked by an engineer in an apartment house how to get more hot water through the pipes. I told him to heat it more and send it up hotter and perhaps the tenants would use more cold with it and less hot water. He heated the water automatically with the exhaust from a lighting engine and an elevator pump. I saw him a few weeks after and he said everything was working satisfactorily.

Auburn, Mass. C. W. PETERS.

Inquiries of General Interest

Reconnecting Induction Motors—Can a 60-cycle, 550-volt, three-phase induction motor be reconnected to operate on 440 volts two-phase? The machine now runs 480 r.p.m. at full load, has 168 coils in the winding, connected in single-circuit star. N. W. W.

The winding as now connected has 14 poles grouped four coils per pole per phase. By regrouping the winding for two-phase 6 coils per pole per phase, connected in series, the motor will operate on a 440-volt two-phase circuit. The two-phase voltage is 80 per cent. of the three-phase volts, and the winding as reconnected will operate on 81 per cent. of the three-phase volts, or $550 \times 0.81 = 445.5$ volts, consequently this will be satisfactory for 440 volts.

Calculating Power Factor—Our alternators are three-phase, 600-volt, 1500-kw. machines. If the wattmeter indicates 1300 kw. and the ammeters each read 2000 amperes, what would the power factor be? Is low power factor the cause of poor voltage regulation? E. Mc.

The kilovolt-amperes of a balanced three-phase circuit is kv.-a. $= \frac{EI \times 1.732}{1000}$, where E is the volts between terminals and I the current in amperes per terminal. Then in this problem kv.-a. $= \frac{600 \times 2000 \times 1.732}{1000} = 2018.4$. The power factor (p. f.) equals kilowatts (kw.) divided by the kilovolt-amperes (kv.-a.), or p. f. = kw. $\div$ kv.-a. $= 1300 \div 2078.4 = 0.62$. Low power factor is one of the causes of poor voltage regulation. A power factor of 0.62 is considerably lower than would be considered good operating practice.

Increase of Power for Pumping Additional Delivery—If a pump raises 150 gal. of water per minute to a height of 25 ft., how much more power will be required if the pressure is increased sufficiently to elevate one-sixth of the water 12 ft. higher, or a total height of 37 ft.? P. F. K.

To raise the water to a height of 25 ft. would require the pump to work against a head of 25 ft. plus the head lost in overcoming pipe friction, and to raise any portion of the pump discharge to a height of 37 ft. would require the pump to discharge the whole delivery, or $150 \times 1\frac{1}{6} = 175$ gal. per min., against a head of 37 ft. plus the head lost in pipe friction; and the original 150 gal. per minute would be discharged under a head of 12 ft. plus the additional head lost in pipe friction due to delivery of the one-sixth more water. Neglecting pipe friction, an increase of head from 25 to 37 ft. would require $\frac{37}{25}$ as much power and for increasing the pump discharge from 150 to 175 gal. per min. would require $\frac{175}{150}$ as much power, so that $\frac{37}{25} \times \frac{175}{150} = 1.726$ times as much, or 72.6 per cent. more power would be required.

Temperatures Within Boiler Water Column—In a water column of a boiler carrying steam at a gage pressure of 125 lb. per sq.in., what would be the temperature of steam in the water column $\frac{3}{4}$ in. above the level of the water and the temperature of the water $\frac{3}{4}$ in. below the surface covered by steam? J. V. H.

For all practical purposes the temperature $\frac{3}{4}$ in. above or below the surface of the water would be the same as that of dry saturated steam at a pressure of 125-lb. gage; namely, 353 deg. F. Radiation of heat usually is taking place from the steam connection of water columns of boilers while under steam pressure, and consequently there is slightly less pressure and lower temperature of the steam at or near the water level in the column and gage-glass than the temperature of steam and of water in the boiler; but ordinarily, the difference would be imperceptible. However, the column might be so exposed to cold that the water any distance below the surface would be considerably lower in temperature than the temperature of the steam, depending on circulation and insulation. The temperatures are controlled by the same principles as those which determine temperatures within pipes and radiators of a two-pipe gravity-return steam-heating system. The steam connection of the water column corresponds to the supply line, the steam space corresponds to the radiators and portions of the system not flooded with water, and the water connection of the water column corresponds to the flooded return pipes of the heating system, which may become sufficiently chilled by the surrounding atmosphere for the water within them to become frozen from the radiators clear back to the boiler.

Determining Size of Motor Required for Fan Blower—We have a 42-in. diameter fan blower which, when driven at 750 r.p.m., will handle 20 to 25 tons of ensilage per hour and elevate it 30 ft. According to the manufacturers, the blower doing that work required four to six horsepower. We have increased the speed to 1200 r.p.m. and handle the same quantity of material per hour elevated 62 ft. The blower is driven by an engine and we wish to change to motor drive. What size of motor should be provided? B. H.

The data and conditions are not sufficiently complete and exact for deciding the probable characteristics of operation of the blower. The best method of determining the size of motor to be used would be to ascertain the power required by indicating the engine while carrying a constant load with and without the blower. The difference will be the power required for the blower. Another method is to measure the power with some form of transmitting dynamometer. Other ways of testing would be by substitution of an ascertainable brake load. If the power taken by the blower is more than about one-fourth the capacity of the engine, run the blower doing regular work, using the regular throttle valve for starting and stopping the engine, and with a stop-valve between the regular engine throttle and the boiler, but with the regular throttle wide open, throttle down the supply of steam to a point where the blower doing regular work will be driven only just up to proper speed. Then, without changing the position of the stop-valve, stop the engine by closing the regular throttle valve, remove the belt from the blower and apply a prony brake to a pulley on the blower countershaft and determine the greatest brake power that can be developed by the engine with full throttle, the same opening of the stop valve and the same steam pressure as before on the boiler side of the stop-valve.

If it is impracticable to thus employ a stop valve for gaging the flow of steam under identical conditions, so as to obtain the same development of power when the engine carries the substituted brake load, another method is to drive the blower countershaft with a slack belt brought to the necessary tension with a weighted tightener-idler pulley by means of which the tension of the countershaft driving belt may be made only just sufficient for driving the blower to the proper speed. It then can be ascertained how much prony brake load can be laid on the countershaft as a substitute for the blower load under the same conditions of belt tension.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Synchronous-Motor Drive for Ice Machines

THE manufacture of ice and refrigeration is increasing rapidly in this country at the present time, and the cost of power is a very large item in the value of finished product. In fact, there is more primary power used per $1000 of product in the manufacture of ice than in any other industry. Census reports of 1914 (in ice-manufacturing plants) showed 7.64 of installed primary horsepower to every $1000 of annual product.

Many ammonia compressors ranging from 100 hp. up are now being equipped with direct-connected synchronous motors. A synchronous motor is the only type that is practical to use at the slow speeds required. What are called low motor speeds (say around 200 r.p.m.) are high compressor speeds; in fact, it is only within the last few years that it has been made possible to build compressors with speeds of 200 r.p.m. or higher. This was mostly due to the development of the high-speed plate valve with low lift. A better system of lubrication for reciprocating parts has also helped. Actual piston speed has not been materially increased because the length of stroke is correspondingly reduced on high-speed compressors. Large steam-driven compressors were operated at varying speeds according to the output of ice required. Sometimes the speed was as slow as 20 r.p.m.—sometimes went up to 80 or 90 r.p.m. or higher.

Variable Speed of Ice Machines No Longer Necessary

Most engineers admit that it is no longer necessary to provide for variable speed of the ice machines in order to take care of fluctuating demands for ice. Plants are planned with a number of constant-speed compressor units which can be operated singly or in parallel so that any desired ice-making capacity can be secured. For instance, a typical plant with 400 tons daily capacity (ice) might have four compressors—one rated at 150 tons, two at 100 tons each and one at 50 tons. With such an arrangement the daily output could be maintained at any desired amount in tons—50, 100, 150, 200, 250, 300, 350 or 400. The machines would always be running at constant speed and practically full load, at their highest efficiency.

An ammonia compressor is a reciprocating machine with heavy moving parts and has an oscillating torque curve very similar to that of a steam engine. The load increases toward the end of the stroke and this recurs at regular intervals, so that unless something is done to damp out this peak it may start the motor to oscillating.

Sufficient flywheel effect should be supplied to reduce the angular displacement of the poles at these periodic intervals to about three electrical degrees. In order to give a clear idea of what this means, consider the displacement reduced to inches. The distance from the center of one pole to the center of the adjoining pole on a rotor is 180 electrical degrees. On a 36-pole (200-r.p.m.) motor this distance might be, say, 5.5 in.—three electrical degrees would be less than 0.1 of an inch. The rotor could slide back only this small space at the end of each stroke—and of course it would have to regain this during the return stroke so as to be ready to slide again when the piston approached the opposite end of the cylinder (speaking now of a double-acting compressor).

The flywheel, as you know, can act only during a change of speed—and the change of speed allowed in this case is limited by the motor characteristic to a very infinitesmal amount—the time it would take the rotor to drop back 0.1 of an inch.

We, as motor builders, are not prepared to say what is the proper flywheel effect that should be supplied to a certain compressor; that, we believe, is the function of the engineer who designs the machine. We know that it is advisable to keep a difference of at least 20 per cent. between the natural frequency and the forced frequency (r.p.m.).

*Abstract from a paper read by J. R. Watson, Mar. 19, 1919, before the Engineers' Society, Milwaukee, Wis., under the auspices of the Milwaukee Section of the American Society of Refrigerating Engineers.

When compressors are diven by direct-connected steam engines there is a combination of two oscillating torques—that of the reciprocating engine and that of the reciprocating compressor. In some cases the torque of the engine piston is diminishing at the time when the torque required by the compressor piston is increasing. Under such circumstances the flywheel must be designed to take care of smoothing out the unevenness, both on the engine end and the compressor end.

But with the synchronous motor conditions are entirely different. The motor delivers to the compressor a smooth, even flow of power. It has no low point or dead-center such as in the case of the engine. Consequently, it does not require the flywheel to assist it to anything like the same extent. As a matter of fact the line itself acts as a flywheel to carry the motor over sudden loads. It is desirable to hold down these jerks of power on the line, and of course the flywheel does help materially in smoothing them down. It should be remembered that the central station's attitude today is somewhat different from that of a few years ago. Systems are now so large and the diversity factor of various loads is such that they can stand a great deal more from a motor than was formerly allowed. For instance, a large power customer with a number of big motors would probably have no difficulty in starting any one of his motors singly even if they should take quite a large kv.-a. from the line.

Advantages of Direct-Connected Motor

It seems hardly necessary among ice and refrigerating men to spend much time outlining the advantages of having the motor direct-connected to the compressor. All the auxiliary equipment of belts, ropes, pulleys, etc., is eliminated. Floor space is valuable in artificial ice plants, which are generally in downtown sections of large cities where ground is very expensive. Nearly all the space formerly occupied by the driving engine can be gained. This means a saving of 30 to 40 per cent. in floor space.

Of course the greatest argument in favor of direct connection is the saving in power by the cutting out of all transmission losses. These power losses in an average plant are seldom less than 10 per cent. and may run as high as twice this amount. The tremendous saving in yearly power bills is what interests all engineers. The efficiencies on unity-power-factor synchronous motors are remarkably high, and this is the compelling reason for the refrigerating engineer. For instance, a certain 560-hp. 225-r.p.m. motor driving a compressor tested as follows: Efficiency at one-half load, 95.6 per cent.; three-fourths load, 98 per cent.; full load, 96 per cent.; and 125 per cent. full load, 95.4 per cent.

Economy of Direct-Connected Synchronous Motor

It is believed that it can be definitely proved that the most economical drive for an ice machine is a direct-connected synchronous motor. The discussion has been limited to direct-connected units only. There are many belted synchronous motors driving ammonia compressors that also operate at high efficiency and unity power factor. It is sometimes necessary, from the nature of the conditions, to use a belted motor, as when a very slow-speed old-style compressor is to be driven. Compressor speeds around 200 r.p.m. have been spoken of. It is possible that in the future synchronous motors may be direct-connected at speeds considerably lower than this. It is known to be feasible to design and build a motor with as low as one kilowatt capacity per pole. If it should be found advisable to use slower speeds than those mentioned, motors could be designed for direct connection.

In the case of an isolated plant generating its own alternating current, the use of an overexcited synchronous motor at a leading power factor is often desirable. Such a motor, if properly designed, may operate at a power factor, say, 80 per cent. leading while at the same time carrying 0.75 of its rated mechanical load in horsepower. The motor under this condition may exert nearly the maximum of

corrective effort on the system's power factor. (The condition of the system as to kv.-a. capacity and power factor must be taken into consideration.)

This matter of power-factor improvement cannot be met in the future as it has been in the past, simply by the central station installing large synchronous condensers. It will become more and more desirable to have a connected load of many fair-sized synchronous motors scattered over the system. This is much better from the standpoints of voltage regulation, transmission efficiency, etc., than the old method of combining all the power-factor correction for the circuit in one or more synchronous condensers.

The result will be that central stations will encourage the use of synchronous motors more and more on their lines. This tendency is already apparent in many sections of the country, especially where heavy individual users of power are scattered over the system.

Growth in the Electric Light and Power Industry

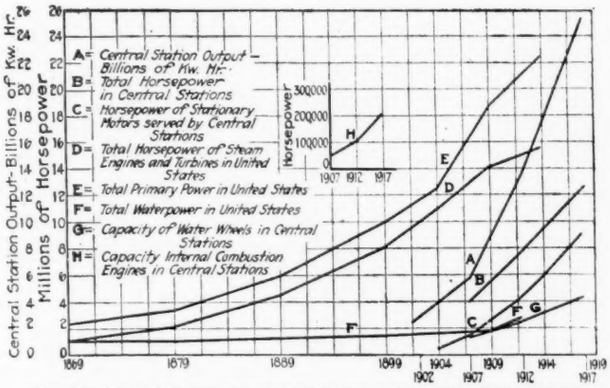
According to a report about to be issued by Director Rogers, of the Bureau of Census, Department of Commerce, the electric light and power stations in the United States during 1917 generated more than twenty-five billion kilowatt-hours of electric energy, producing an income of more than a half billion dollars, and gave employment to more than 100,000 persons, whose salaries and wages aggregated nearly $100,000,000. The output in 1917 was more than double that for 1912 and more than quadruple the output for 1907.

This report, which was prepared under the supervision of Eugene F. Hartley, chief statistician for manufactures, covers both commercial and municipal plants, but does not cover electric plants operated by factories, hotels, etc., which generate current for their own consumption, plants operated by the Federal Government and state institutions, nor plants that were idle or in course of construction at the time of the investigation.

The figures show great strides in the industry during both of the five-year periods 1907-12 and 1912-17. The output of electric energy by the light and power stations increased at a considerably greater rate, and their expenses at a slightly greater rate, than their incomes; the rate of increase in the number of persons employed was much smaller, particularly during the later five-year period, than that in the amount of business done.

The total number of establishments increased from 5221 in 1912 to 6541 in 1917, the latter comprising 4224 commercial and 2317 municipal establishments. The increase indicated by these figures is somewhat misleading, since 2296 new establishments came into existence between 1912 and 1917, but as a result of combinations in the commercial systems and various other changes the net increase was only 1320, comprising 565 commercial and 755 municipal stations.

The total income of the stations in 1917, of which 95.3 per cent. represented electric service, amounted to $526,886,408, an increase of 74.3 per cent. as compared with 1912 and of 200 per cent. as compared with 1907. The total expenses



TREND OF POWER INDUSTRY IN THE UNITED STATES
COMPILED FROM SEVERAL SOURCES

were $427,136,049, or 82.1 per cent. more than in 1912 and 218.3 per cent. more than in 1907. The employees of the light and power stations numbered 105,546, an increase of 33 per cent. over 1912 and of 121.6 per cent. over 1907; and their salaries and wages aggregated $95,239,954, an increase of 55.7 per cent. as compared with 1912 and of 168.9 per cent. over 1907.

ELECTRIC LIGHT AND POWER STATIONS, 1917, UNITED STATES

	1917	1912	1907	Per Cent. of Increase * 1907 to 1917	1912 to 1917	1907 to 1912
Number of establishments	6,541	5,221	4,714	38.8	25.3	10.8
Commercial	4,224	3,659	3,462	22.0	15.4	5.7
Municipal	2,317	1,562	1,252	85.1	48.3	24.8
Income	$526,886,408	$302,273,398	$175,642,338	200.0	74.3	72.1
Electric service	$502,100,346	$287,138,657	$169,614,691	196.0	74.9	69.3
All other	$24,786,062	$15,134,741	$6,027,647	311.2	63.8	151.1
Total expenses, including salaries and wages	$427,136,049	$234,577,277	$134,196,911	218.3	82.1	74.8
Number of persons employed	105,546	79,335	47,632	121.6	33.0	66.6
Salaries and wages	$95,239,954	$61,161,941	$35,420,324	168.9	55.7	72.7
Total horsepower	12,857,998	7,530,044	4,098,188	213.7	70.8	83.7
Steam engines:						
Number	7,464	7,847	8,054	—7.3	—4.9	—2.6
Horsepower	8,389,389	4,949,778	2,693,273	211.5	69.5	83.8
Internal-combustion engines:						
Number	2,946	1,116	463	536.3	164.0	141.0
Horsepower	217,186	111,035	55,828	289.0	95.6	98.9
Waterwheels:						
Number	3,357	2,939	2,481	35.3	14.2	18.5
Horsepower	4,251,423	2,469,231	1,349,087	215.1	72.2	83.0
Kilowatt capacity of dynamos	9,001,872	5,165,439	2,709,225	232.2	74.3	90.7
Output of stations, kilowatt-hours	25,438,611,417	11,569,109,885	5,862,276,737	333.9	119.9	97.3
Stationary motors served:						
Number	554,917	435,473	167,184	231.9	27.4	160.5
Horsepower	9,216,323	4,130,619	1,649,026	458.9	123.1	150.5
Number of street lamps:						
Arc	256,838	348,643	†	.....	—26.3	
Incandescent, etc	1,389,382	681,957	†	.....	103.7	

* A minus sign (—) denotes decrease. † Not available.

Fuel-Oil Prices to Shipping Board

The Director of Operations has awarded the following fuel-oil bid for United States Shipping Board vessels to be taken during the next twelve months. Quantity not fixed. All U. S. S. B. vessels loading at Port Arthur, Texas.

Delivery and Grade	Price per Bbl., 42 U. S. Gal.
No. 1 "B"	$0.84
No. 1 "C"	.74
No. 2 "B"	.84
No. 2 "C"	.74
Plus 10c. per bbl. for lighterage, subject to minimum charge of $500.	
No. 3 "B"	$0.84
No. 3 "C"	.74
Plus rail freight, refinery to wharf, f.o.b. tank cars	

In a series of tests made to determine the light-transmitting properties of fresh water, it was found that, taking the illuminant at the surface of the water as 1, approximately 0.75 part would be transmitting through 1 ft. of water, at 5 ft. 0.20 part, and at 100 ft. only about 0.000,000,000,000,01 part of the total illuminant at the surface reaches this depth.

Electrical and Illuminating Engineers Hold Joint Meeting

On Friday evening, Apr. 11, 1919, the American Institute of Electrical Engineers held its 349th regular meeting. This meeting was held under the auspices of the Lighting and Illumination Committee of the A. I. E. E. and was a joint meeting with the Illuminating Engineering Society. One paper, "Present Status of Industrial Lighting Codes," presented by G. H. Stickney, gave an outline of the necessity and scope of industrial lighting codes together with an analysis of the specifications of such items as the intensity, limits of glare and distribution of illumination as related to modern industrial lighting. The paper discussed the industrial lighting codes based on the Illuminating Engineering Society's code, now enforced in Pennsylvania, New Jersey, New York and Wisconsin. It also referred to the coöperative work between the Departments of Labor, Industrial Commissions and other agencies charged with the enactment and enforcement of regulations regarding industrial lighting.

Comfort A. Adams, president of the American Institute of Electrical Engineers, presided. In his opening remarks he referred to the many difficulties in establishing a lighting code satisfactory to all parties interested and said that those who have done the work on the code, referring to that of the Illuminating Engineering Society, should get considerable comfort out of their work, for they have performed a real public service.

Repairing Boilers by the Electric or Oxyacetylene Process

The British Board of Trade has published for official use an instruction to surveyors of vessels on the subject of making repairs to the boilers of passenger steamers by the electric or oxyacetylene process, as follows:

The repairing of the boilers of passenger steamers by the electric and oxyacetylene processes has been tentatively in operation for a considerable period and, in view of the experience gained, the surveyors are informed that, provided the work is carried out to their satisfaction by experienced workmen, these processes may be employed, within limits, for repairing cracks in furnaces, combustion chambers and end plates of boilers, and in the same parts for reinforcing the landing edges of leaky riveted seams which have become reduced by repeated chipping and calking.

In some old furnaces which have been repaired by these processes it has been found that, after a few months' working, cracks have again developed at parts adjacent to those welded, probably owing to the original material of the furnace having become fatigued and worn out by long and severe usage. In dealing with old furnaces, therefore, this fact should be taken into consideration.

It has also been brought to the notice of the board of trade that a shell plate of a cylindrical marine boiler cracked recently through a solid part where some surface welding had been done by the electric process two years ago. The welding had extended for a length of about 12 in. along the outside calking edge of one of the middle circumferential seams at the bottom of the boiler, the leaky edge of the seam and the adjoining shell plate having been covered (soldered) by metal deposited by this process in the usual way. The shell plate was 1$\frac{5}{32}$ in. thick and the crack, which followed the line of surface welding, extended in a circumferential direction for a distance of 2 ft. 9 in., the welded part being situated midway along the crack.

For the present it is not proposed to prohibit, within limits, the reinforcement of the circumferential seams of boiler shells if the end plates are well stayed, but no welding should be done to these parts by any process which may cause local heating over an appreciable area of the plate, such as the oxyacetylene, oxyhydrogen, or other similar methods. In no circumstance should any part of a boiler of a passenger vessel be welded if wholly in tension under working conditions, such as a stay or the shell plate at a longitudinal seam, the failure of which by cracking at the welded part may lead to disastrous results.

In any case in which the proposed repairs to the boilers of passenger vessels by either of these processes are of an uncommon or unusually extensive character, the particulars should be submitted for the board's consideration and approval.

After repairs by welding have been completed, the parts at or adjacent to the welds should in all cases be well hammer tested; and, and unless the welding is of a trifling character, a hydraulic test of not less than one and a half times the working pressure should be applied to the boiler after the hammer testing has been effected.

Brains Versus Brawn

Observing that a young workman on an excavation job was accomplishing about twice as much work as any one of his fellows, the superintendent kept a close eye on him. When a problem was presented of lifting a heavy piece of steel from a point one hundred feet beyond the reach of the derrick boom, every workman was called to the task. After a few minutes of fruitless effort the zealous one suggested that the boom be lowered to the ground. He then led the cable to the steel beam and fastened it. The engine started, easily drawing the beam along until it reached the boom-end. The boom was then raised in the usual way and the big steel piece which had defied the concerted strength of twenty husky workmen was quickly lifted and deposited on a waiting truck.

Noting the quick-witted young man's action, the "super" inquired of him where he had picked up his engineering ability.

"In the army," replied the worker. "This is nothing to what we engineers did in France."

"Well, my boy," said the superintendent, "tomorrow you go on our payroll as a construction foreman."—*The Wall Street Journal Straws.*

First Assistant Engineers Wanted

The United States Shipping Board wants first assistant engineers. There is a present shortage in this grade in the merchant marine and highly paid positions are ready for men who can fill them. Qualified applicants are directed to report to the Sea Service Bureau at any large American port.

Owing to the great demand for officers in the grades mentioned, the Shipping Board has ordered its officers' training schools to accept for intensive training any merchant marine officer who wishes to brush up in preparation for examinations for a raise in grade, and second mates and second assistants are urged to take these courses in order to shorten the time in which they may obtain first mates' or first assistant engineers' licenses.

Schools for engineers are now opening new classes for a month's training. The following technical colleges are giving such courses: Massachusetts Institute of Technology, Cambridge, Mass.; Case School of Applied Science, Cleveland; Armour Institute, Chicago; Tulane University, New Orleans; University of California, Berkeley; University of Washington, Seattle.

It has been found that by keeping hot water under pressure in contact with a large surface of iron for a sufficient length of time, it is possible to remove and fix the oxygen contained in the water and thus render the latter practically noncorrosive. The successful application to practical uses of this method, devised by F. N. Speller, metallurgical engine of the National Tube Co., has been demonstrated in the heating system at the Irene Kaufmann Settlement in Pittsburgh, where test lengths of uncoated wrought-iron and steel pipe have been reëxamined after two years' service and found to be practically uncorroded. Duplicate pipe in the same system, but unprotected in this way, showed considerable corrosion.

The *Electrical Engineer*, London, mentions a novel method of cleaning condenser tubes by blowing through them water with sand in suspension. Originally, an air pistol was used to project the water, but subsequently sand was introduced by means of the circulating water, about 1$\frac{1}{2}$ cu.yd. being added to the water daily. After three weeks of this treatment, it is said the condition of the condenser was much improved. The size of the condenser is not stated.

Engineering Affairs

The Indiana State Association of the N. A. S. E. will hold its convention at Terre Haute, Ind., on June 26, 27 and 28.

The Master Boiler Makers' Association will hold its annual convention at the Hotel Sherman, Chicago, May 26 to 29.

The Association of Iron and Steel Electrical Engineers, Pittsburgh Section, will hold a meeting on Apr. 26, at Chatham Hotel. A paper entitled "Electricity Afloat; Steel Mill Practice Applied in the Navy" will be read by Lieut. A. M. McCutcheon, U. S. N.

The Association of Iron and Steel Electrical Engineers, Chicago Section, will hold a meeting on Apr. 26, at the Great Northern Hotel. A joint paper, "Safety in Steel Mills," will be read by C. M. Brading, superintendent of safety, and F. A. Wiley, electrical superintendent, Wisconsin Steel Co., South Chicago, Ill.

The New York Chapter of the American Association of Engineers will meet at 8 p. m., Wednesday, Apr. 23, in the United Engineering Societies Building, 29 West 39th St. The speaker will be Dr. George W. Kirchwey, Director of the United States Employment Service, and his subject will be "Solving the Unemployment Problem."

The American Society of Heating and Ventilating Engineers, at a meeting of the Council on Apr. 7, decided to hold its semi-annual meeting at Pittsburgh, Penn., on June 10, 11 and 12. This meeting is to be held jointly with the annual convention of the National District Heating Association. Announcement of the headquarters will be made later.

Business Items

A. P. Green Fire Brick Co., of Mexico, Mo., has opened an Eastern district sales office in New York City at 30 Church St., with Howard C. Thayer, formerly field mechanical engineer for the J. G. White Engineering Corp. at U. S. Nitrate Plant No. 2, in charge.

The Schenectady Power Co., the Mohawk Gas Co. of Schenectady, the Edison Electric Light and Power Co. of Amsterdam, and the East Creek Electric Light and Power Co. have merged into the Schenectady Illuminating Co. under orders passed by the public-service commission. The merger of the corporations has been under way for several years, and is a step in the proposed consolidation of the Schenectady Illuminating Co. and the Adirondack Electric Power Corp., which controls extensive hydro-electric power developments on the upper Hudson River. The latter consolidation is now pending before the commission. Electric-current distribution in parts of five counties—Schenectady, Rensselaer, Montgomery, Fulton and Herkimer—has now been brought under one management and control, resulting in greater distribution, improved service and reduced demands on auxiliary steam plants, operated with coal.

Trade Catalogs

The Corliss Carbon Co., of Bradford, Penn., has just published Bulletin No. 6, which gives complete up-to-date data on brushes in condensed form. A copy may be had by addressing the company.

The American Malleable Castings Association, Cleveland, Ohio, has issued a booklet entitled "Malleable Iron." This is only the forerunner of a more comprehensive volume to be issued later; nevertheless it is filled with valuable data. A copy will be sent gratis, on request, to anyone mentioning this paper.

Schweitzer & Conrad, Inc., of Chicago, Ill., has issued a catalog describing high-voltage protective and switching equipment. It is divided into five sections—Bulletins Nos. 101, 102, 103, 104 and 105. Bulletin No. 101 treats of fuses and switches; No. 102, circuit breakers; No. 103, cutouts; No. 104, lightning arresters; No. 105, detectors, relays and synchronoscopes.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.80@3.35
Philadelphia, gross tons	4.20@4.90	5.00@5.40
New York, gross tons	4.50@5.25	5.35@5.80
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.65

Pocahontas and New River are quoted at $4.70 @5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports* are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$5.95	$7.80	Pea	4.80	6.55
Egg	5.85	7.70	Buckwheat	3.40	5.15
Stove	6.10	7.95	Rice	2.75	4.50
Chestnut	6.20	8.05	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.80 @ 3.10	2.95 @ 3.25
Clearfield County	2.65 @ 2.95	.....
Reynoldsville	2.65 @ 2.85	2.85 @ 2.95
Quemahoning	2.75 @ 2.95	2.95 @ 3.10
Somerset County (best grades)	2.75 @ 2.95	2.95 @ 3.10
Somerset County (poorer grades)	2.25 @ 2.50	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2.10 @ 2.35	2.35 @ 2.50
Latrobe	2.10 @ 2.25	.....
Greensburg	2.35 @ 2.40	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.65 @ 2.75
Westmoreland run-of-mine	2.40 @ 2.65	2.40 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.85	7.70	Rice	2.75	3.65
Stove	6.10	7.95	Boiler	2.50	3.50
Nut	6.20	8.05	Barley	2.25	3.15
Pea	4.80	6.40	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois f.o.b. Mines	Northern Illinois f.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@ 2.50	3.00
Screenings	1.85@ 2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

Franklin County	Mt. Olive and Staunton	Standard
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....	.....
Williamson County			
Prepared sizes, lump, egg, nut	$2.55	$2.55	$1.90@2.25
Mine-run	2.35	2.20	2.00
Screenings	2.20	2.05	1.75
3-in. lump	....	2.30	.....
2-in. lump	....	....	2.15

Williamson-Franklin rate to St. Louis is $1.07½; other rates 92½c.

New Construction

PROPOSED WORK

Mass., Foxboro—The State of Massachusetts is having plans prepared by R. D. Kimball Co., Engr., Beacon St., Boston, for the construction of a heating and power plant to be installed in connection with the 3-story, 50 x 160 ft. hospital which it plans to build on the State grounds here.

Mass., Springfield—The New York, New Haven & Hartford R. R., New Haven, Conn., plans to build a boiler plant at the freight yards here. Estimated cost, $25,000. E. Gagel, New Haven, Conn., Ch. Engr.

Conn., Bridgeport—H. E. Frank, 426 Boston Ave., will install a steam heating plant in the 4-story, 170 x 194 ft. apartment hotel which he plans to build on Washington Ave. and Coleman St. Total estimated cost, $200,000. E. B. Cladwell, 886 Main St., Arch.

Conn., New Haven—A. Gingold, 23 Church St., will install a steam heating plant and vacuum cleaning system in the 5-story, 73 x 110 ft. apartment hotel which he plans to build on Orange St. Total estimated cost, $100,000. C. J. Bailey, 94 Church St., Arch.

Conn., New Haven—The Marlin-Rockwell Corp., Whitney Ave., will install a steam heating plant and electric power in the 1-story, 160 x 180 ft. foundry which it plans to build. Total estimated cost, $100,000.

Conn., New Haven—A. D. Mullen, 42 Church St., will install a steam heating plant in the 4-story, 70 x 155 ft. apartment hotel which he plans to build on Crown and High St. Total estimated cost, $100,000. W. A. Donovan, 3 Colony St., Meridan, Arch.

N. Y., Attica—The Genessee Light & Power Co., Batavia, plans to issue $220,000 bonds; $88,000 of this amount will be spent for the construction of a power line from Batavia via Attica to Le Roy.

N. Y., Batavia—The Batavia Pure Ice and Storage Co., recently incorporated by P. J. Marion, F. W. Garnier and N. J. Schultz, has purchased the ice and storage plant of W. W. Buxton and will increase the capacity of ice-making machinery from 12 to 18 tons per day for its own use.

N. Y., Brooklyn—H. Spiegel, c/o the Sheffield Theater, 308 Sheffield Ave., will install a steam heating plant in the 2-story, 100 x 200 ft. theater which he plans to build on Stone Ave. near Pitkin St. Total estimated cost, $100,000. Zipkes, Wolf & Kudroff, 25 West 42nd St., Manhattan, Arch.

N. Y., New York—The Chicago Pneumatic Tool Co., 343 South Dearborn St., Chicago, Ill., will install a steam heating plant in the 12-story, 50 x 90 ft. office building which it plans to build at 6-8 East 44th St. Westinghouse, Church & Kerr, 37 Wall St., engr.

N. Y., New York—B. S. Moss Co., 729 7th Ave., will install a steam heating plant in the 2-story, 137 x 161 ft. theater which it plans to build on 181st St. and Broadway. Total estimated cost, $475,000. De Rosa & Pereira, 110 West 40th St., Arch.

N. Y., Oneida—The Building Committee of the Broad St. Hospital will install a steam heating plant and forced ventilating system in the nurses' home which they plan to build in connection with the hospital. Total estimated cost, $50,000.

N. J., Trenton—Essenwein & Johnson, Archts., Ellicott Sq., Buffalo, N. Y., will install a steam heating plant in the 9-story, 110 x 200 ft. hotel which they plan to build here. Total estimated cost, $1,000,000. O. E. Goldschmidt, 116 West 39th St., New York City, Engr. Owner's name withheld.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to install heating and humidifying apparatus in Building "D" here. Estimated cost, $75,000.

Penn., Tamaqua—The M & G Ice and Ice Cream Co. will soon receive bids for the construction of a 30-ton ice plant. Machinery and equipment will be installed in same. Estimated cost, $50,000. B. R. Stevens, 1737 Filbert St., Arch.

Md., Baltimore—The Standard Oil Co., Pier 2, Pratt St., will install a steam heating plant in the 6-story, 100 x 100 ft. oil storage warehouse which it plans to build. Total estimated cost, $200,000.

Md., Baltimore—C. M. Stieff, Inc., 9 North Liberty St., will install a steam heating plant in the 3-story, 25 x 110 ft. warehouse which it plans to build at 315 North Charles St. Estimated cost, $100,000. T. W. Pietsch, 1210 American Bldg., Arch.

Md., Baltimore—S. T. Williams, 223 North Calvert St., is in the market for a 150-hp. boiler, with all fittings, 100 lb. pressure; return tube or water tube; also a 250 to 300-kw. generator or engine, direct connected, 250 volts D.C.; D.C. Compound engine; also condenser and air pump, boiler pressure 100 lb.; switchboard, instruments, etc.

D. C., Washington—The Municipal Architect, Room 105, District Bldg., has had plans prepared for the construction of a power house in connection with the new Gallinger Municipal Hospital which will be built here. Total estimated cost, $1,500,000.

Fla., Tallahassee—The city will rebuild the electric light and power plant recently destroyed by fire, entailing a loss of $50,000. C. S. Hammett, Jacksonville, State Engr.

Miss., Hollandale—The Commissioners of Black Bayou D.D., Greenville, will receive bids until May 13th for the construction of a 1-story pumping plant and concrete dam. Morgan Eng. Co., Goodwyn Institute, Memphis, Tenn., Engrs.

Ky., Louisville—The Louisville Water Co. is in the market for coal loading and carrying equipment and the latest labor saving machinery to be installed in the 75 x 150 ft. boiler house which it plans to build at the river pumping station. J. B. Wilson, Ch. Engr.

Ohio, Cleveland—The Board of Education, 340 Leader-News Bldg., will install a steam heating plant in the 3-story, 125 x 200 ft. high school which it plans to build on Lee Rd. Total estimated cost, $300,000. D. B. Carpenter, Pres. F. C. Warner, 768 Hippodrome Annex Bldg., Engr.

Ohio, Cleveland—H. S. Rivitz Co., 2112 Ontario Ave., will install a steam heating plant in the 3-story warehouse which it plans to build on East 40th St. and the N. Y. C. Ry. Total estimated cost, $300,000. C. Schwarzenberg, 1900 Euclid Ave., Engr.

Ohio, Cleveland—Van Aken & Strouck, 6523 Euclid Ave., will install a steam heating plant in the 4-story, 80 x 270 ft. auto sales building which it plans to build on East 66th St. and Euclid Ave. Total estimated cost, $250,000.

Ohio, Euclid—The Board of Education has awarded the contract for the construction of a 2-story school which it plans to build on Berwick Rd. to Drummond & Miller, Guardian Bldg., Cleveland. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ohio, Warren—The J. Warner Hotel Co. will install a steam heating plant in the 8-story hotel which it plans to build. Total estimated cost, $300,000.

Mich., Detroit—The Chicago Pneumatic Tool Co., 343 South Dearborn St., Chicago, Ill., will install a steam heating plant in the 5-story, 60 x 181 ft. office building which it plans to build here. Westinghouse, Church & Kerr, 37 Wall St., New York City, Engr.

Ill., Chicago—The Ravenwood Hospital Association, 1917 Wilson Ave., will install a steam heating plant in the 6-story, 150 x 200 ft. addition to the hospital on Winchester and Wilson Ave. Total estimated cost, $400,000. W. H. Pruyn, Jr., 122 South Michigan Ave., Arch.

Ill., Woodstock—The Oliver Typewriter Co. is in the market for a belt drive, single cylinder, horizontal air compressor.

Wis., Kenosha—The Board of Education will install a steam heating plant in the 2-story, 140 x 180 ft. school which it plans to build. Total estimated cost, $200,000. J. D. Chubb, 109 North Dearborn St., Chicago, Ill., Arch.

Ia., Des Moines—The Des Moines Water Co. plans to build a boiler house and will install a 300-hp. boiler and stokers. Alvord & Burdick, 8 South Dearborn St., Chicago, Ill., Engr.

Minn., Brainerd—The city will receive bids until May 8 for improvements to the waterworks. Project includes the construction of a pumping station with electric pump equipment. Total estimated cost, $250,000. L. P. Wolff, 1000 Guardian Life Bldg., St. Paul, Consult. Engr.

Minn., Duluth—The United Yard & Terminal Association, 5823 Oneida St., will install a steam heating plant in the 3-story, 100 x 140 ft. building which it plans to build. Total estimated cost, $100,000. C. C. Randall, Pres.

Minn., Minneapolis—The Mill City Investment Co. will install a steam heating plant and fan ventilating system in the 3 story, 110x127 ft. theatre and hall which it plans to build on Lake St. near Nicollet St. Total estimated cost, $100,000. D. C. Swain, Plymouth Bldg., Arch.

Minn., St. Paul—The North American Casket Co. will install a high pressure boiler, dry kiln, etc., in the 1-story, 50 x 230 ft. factory which it plans to build. Total estimated cost, $50,000. H. Firminger, 408 Oppenheim Bldg., Arch.

Minn., Winona—The city plans to install additional water supply facilities, to consist of air lift pumps and compressors. Alvord & Burdick, 8 South Dearborn St., Chicago, Ill., Engr.

Kan., Sedan—The Sedan Electric Light & Power Co. plans to build extensions to its power plant. Estimated cost, $32,000. Address M. W. Hartzell.

Neb., Lincoln—The city voted $100,000 bonds for the construction of a main intercepting sewer. Plans include the installation of centrifugal pumps or ejectors. A. Dobson, 945 D St., City Engr.

Neb., Omaha—The Board of Education will install a heating and power plant and probably 4 boilers in the new High School of Commerce which it plans to build. F. W. Clark, 623 Brandeis Bldg., Arch.

N. D., Fargo—The city voted $150,000 bonds for the construction of a light plant. F. L. Anders, City Engr. Noted Mar. 18.

Mont., Ronan—C. C. Beach has been granted a franchise to build an electric light and power plant.

Mo., St. Joseph—The Conser Laundry, 908 Francis St., is in the market for an entirely new power plant, to consist of 2 boilers of tubular type, 18 x 72 ft., 1 direct connected generator unit, 2 pumps, a feedwater heater, a water softening plant and other appliances, such as oil burners, 12,000 gallon oil tank, etc. H. S. Lewis, Ch. Engr.

Mo., St. Joseph—Swift & Co., Union Stock Yards, Chicago, Ill., plans to build 2-story, 40 x 51 ft. addition to its boiler room here. Estimated cost, $90,000.

Ariz., Phoenix—The High School Trustees plan election to vote on $700,000 bonds for improvements at the high school. Plans include the construction of a new heating plant. Estimated cost, $25,000.

Ont., Ottawa—The Hydro-Electric Commission, 109 Bank St., will soon award the contract for transformer, meters and general electric supplies. Estimated cost, $12,000. J. E. Brown, Engr.

Ont., Toronto—The Polusterine Products Co., 170 Ontario St., is in the market for a 25 hp. steam boiler, 2½ hp. electric motor and a 150 gallon steam kettle.

Ont., Welland—The Provincial Government has authorized bill for the construction of a hydro-electric power line from Welland to Port Colborne via Crystal Beach, Ridgeway to Fort Erie and thence to Niagara Falls. Sir Adam Beck, Minister of Power.

Ont., York—The city will vote on by law April 15 for $200,000, to be used for extension of hydro-electric system high tension lines, distributing system and operation.

H. T., Pearl Harbor—The Bureau of Yards & Docks, Navy Department, Washington, D. C., plans to improve the power plant here. Estimated cost, $80,000.

CONTRACTS AWARDED

Ind., Marion—The city has awarded the contract for installing a 2000 cu.ft. air compressor in connection with extending and improving the wells at the waterworks to Laidlow-Dunn-Gordon Co., Cincinnati, O.

Ill., Chicago—The Illinois Packing Co., 3940 Normal Ave., has awarded the contract for the construction of a meat packing plant on Auburn and 38th St. to J. Rodatz, 209 South La Salle St. Plans include the construction of a 1-story, 50 x 60 ft. power house and refrigeration plant. Total estimated cost, $225,000. Hensheim & McLaren, 37 West Van Buren St., Arch.

Cal., Los Angeles—The Clunes Production Co., 5350 Melrose Ave., has awarded the contract for the construction of a 1-story, 20 x 74 ft. electric shop and generator room and a 1-story, 80 x 150 ft. motion picture stage, to E. Fossler, 6434 Hollywood Blvd.; 2 electric generators will be installed in same. Estimated cost, $15,000.

Cal., San Jose—The Richmond Chase Co. has awarded the contract for the construction of a power house, warehouse, cannery, etc., to Z. O. Field, 167 South 14th St.

Cal., Seal Beach—The city has awarded the contract for the construction of a complete sewer system to Mlagenovich & Gillespie, 219 Bloom St., Los Angeles. Plans include the installation of a rotary pump and motor and 2 auxiliary booster pumps. Estimated cost, $42,000. Noted Mar. 4.

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